CHEMICAL & METALLURGICAL ENGINEERING

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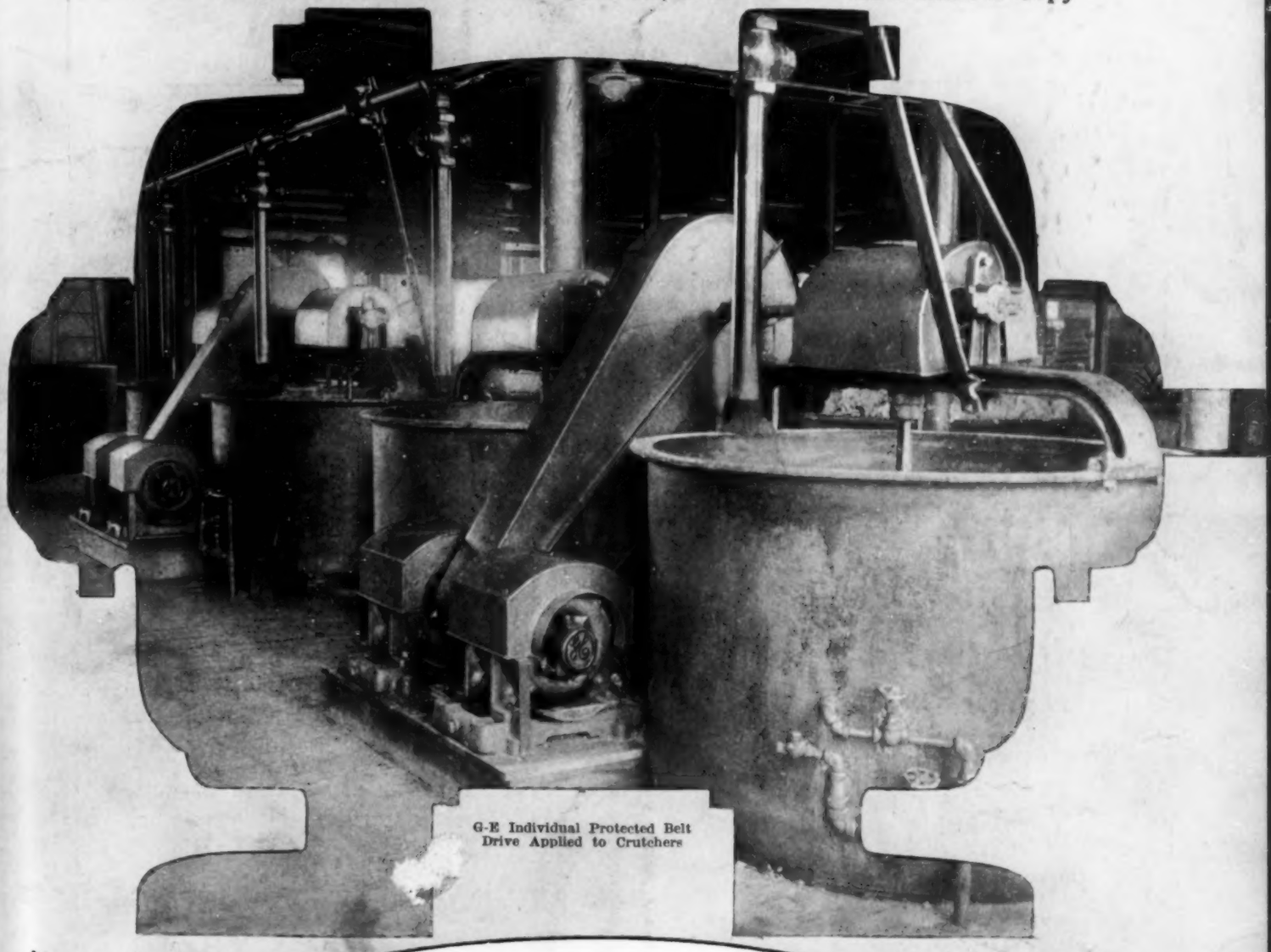

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Talking And Working

A GENTLEMAN of the Central West who has been traveling around the country a good bit in the past few weeks expresses the conviction that Americans have got into a habit of talking too much. Nearly everywhere he went he found a "convention" in session or in prospect, and some of these conventions he attended. The chief aim of the speakers at the conventions was to tell their hearers what was wrong with the United States and the world generally and what other people had to do in order to make things right for us. The same gentleman had been in Europe for a couple of months and he draws a comparison unfavorable to us, saying that the people of France, Belgium and Germany are working hard, while the British are gradually getting to work.

Of course, there are conventions and conventions. It is one thing to tell a gathering of farmers what the gold bugs are doing and another thing to tell what ought to be done to potato bugs. One is constructive and destructive (to the potato bugs), while the other is not even destructive. At a convention of engineers those in attendance get ideas, or should get ideas, whereby when they get home they can do better work. When a convention of business men or farmers is told the various things that are wrong with the United States and numerous other countries and how times will not be good until things are righted, are those in attendance fortified to do harder and better work when they get home?

This is a sort of mob psychology. One does not need to attend meetings or conventions to observe it. We do not escape the talk by avoiding reading the *Congressional Record*, for we encounter it in the daily newspapers, on the street, practically everywhere. It is another form of "the world owes us a living," for it requires no close analysis to see that much of the talk is motivated by the idea "If the rest of the world would just behave itself, I could make some money."

At bottom most of the thoughts expressed are selfish. There is the talk about railroad freight rate reductions. We want to buy our goods more cheaply and have a broader market for the things we want to sell. Before the war the talk was that freight rates ought to be advanced, because we wanted railroad orders. We want conditions in Europe to get settled so that we can sell our goods to Europe. But just think of what the rest of the world could say about us along that line! The rest of the world owes us in funded debt about eleven billion dollars and there is in addition four billion or more of unfunded balance in favor of the United States, making a total of fifteen billion or more, and then men are shouting that they want the rest of the world to get in shape to buy our goods. The rest of the world would like us to provide an opportunity to pay something against what they already owe us. They have sent us this year about half a billion dollars in gold and the gold reserves of the Federal Reserve system are now nearly equal to the combined gold reserves of all other countries, while people in the United States are explaining when they can get listeners that the other countries ought to stabilize their currencies.

Undoubtedly we are talking too much along lines that do not get the talker or the hearer anywhere, but rather encourage a disposition to wait until something turns up, until freight rates are reduced or the French army is disbanded or the German indemnity is paid or Russia gets on its feet or the federal taxing system is revised again. If we really must talk let us talk about working. If we can't find work of the kind we used to do, let us think up something new. The movie shows seem to be getting along quite well. They aim to offer the public something new each week.

We Congratulate Mr. Dawes

THE FIRST budget of the United States Government has been presented to Congress. In many particulars it is an admirable document. And in one particular scientists and engineers should be especially pleased with it—the treatment which has been accorded the technical and scientific work of the federal departments.

The effort in drafting the budget has been to curtail expenses, an effort which every taxpayer will strongly commend. But apparently the effort to reduce the cost of government has not been rashly and recklessly undertaken to the detriment of really worth-while projects. In fact there seems to have been a real distinction made between apparent and real economy in the reduction of expenditures. Of all the technical and scientific bureaus, very few have suffered reduction in the appropriation recommended for their scientific investigations and their constructive engineering effort. There have, indeed, been actual increases recommended for most of these institutions.

For the Bureau of Mines, Patent Office, Geological Survey, Bureau of Standards, Chemical Warfare Service and several others, the increases recommended to Congress for total appropriations are from 5 to 25 per cent greater for the coming fiscal year than the sums which have been provided during the current year. The increases thus provided are intended in some cases for increasing salaries of the scientific staff, notably to increase the standard of salaries paid to the senior members of the staff. Certainly this is a move in the right direction, in order that the quality of the work done by these institutions may not suffer indefinitely because of the wholly inadequate salary scale which has prevailed in many lines. A few new and much needed investigations are also proposed for important scientific and industrial problems of wide interest.

Chicago Business Men Clearing Labor Situation

EVENTS during the past fortnight indicate very clearly that the tide has definitely turned in labor circles. No one set of circumstances has more strongly shown the revulsion against unfair practices on the part of labor than the results obtained by the Citizens' Committee to enforce the Landis award in the building trades, covered in our editorial in the Nov. 23 issue. Chicago, long the stronghold of labor agitators and malicious strike promoters, will harbor these business criminals no longer. Even the more recent strike of the stockyards workers is broken by hordes of hungry men who seek work in the face of physical danger. Another week should mark the end of this phase.

The Landis Award Committee, incorporated in Illinois "not for profit," has now accomplished many things. Fifty-five subdivisions of the Association of Commerce have pledged solid support. The chairman has signed a blanket insurance policy for several million dollars to protect property owners who observe the terms of the award from the vandalism of wrecking crews. Pledges have been given by sixteen mortgage banks that loans will be made only where the Landis award is being followed. A million-dollar loan has recently been denied a big subdivision contractor because of his refusal to abide by the rules.

The carpenters' union situation has been settled by the committee. This union failed to comply with the working conditions and wage scale laid down by Judge LANDIS, and the open shop has been definitely established. A large number of carpenters, more than are actually needed, have deserted the union band-wagon to work for $1 per hour rather than starve.

The committee is calling in violators of the award as rapidly as the scouts can discover them. Of 800 different jobs visited to date, 102 violators have been discovered. On the other hand, the contractors are not allowed to cut wages below the amounts fixed by Judge LANDIS. No mechanic on award jobs need fear that his wages will be slashed below the rate.

All fair-thinking citizens are behind the work. They know the committee is acting for them as a contract enforcer, not as a contract breaker. Arbitrary unionism is dying in Chicago. The year 1922 will be a hard one for strikers. Making the award stick is not only a great thing for Chicago. Precedents are being established that will have a far-reaching effect for better business and happier communities over the whole country.

Organization as a Factor in Research

LATELY we read a report of the Committee of the Privy Council for Scientific and Industrial Research of Great Britain which consisted in a statement of pounds, shillings and pence expended under various heads. Of course we must keep accounts, and watch expenditures, but it is often the habit of the layman to call for figures in regard to the progress of work in laboratories when it is impossible to tell it in figures. Statements of costs may be the poorest possible index of the progress of research. We know of a laboratory, an excellent and fruitful institution, that was nearly upset by a complicated cost system that required of every member of the staff that he record every minute of his time, and charge it to some specific account. This was about as sensible as to ask a commercial traveler to work out his expense account while he is selling goods.

In the British report quoted, the Advisory Council made a supplementary memorandum which met the difficult task of explanation and comment with ability; but the point we desire to emphasize in this connection is that, while expenditures are needed for the prosecution of research, there is a factor of still greater importance which is a far better indicator of progress than a list of expenditures, and that is the organization of the laboratory.

This is the point we want to emphasize. A research laboratory must be a living thing; an organization within itself. We cannot establish it even by selecting men according to their past performances. They must achieve the art of working together. One of the greatest mistakes is to hold that men produce better if they dislike one another and each one wants to get ahead of his fellows in performance. Explanations are necessary as work proceeds, and the habit of working together and of understanding one another among members of a staff makes explanations not only possible, but short. Otherwise an immense amount of unnecessary work is done to no effect, because the man who does it fails to understand its aim.

There is a curious psychology in organization. The greater the number of persons that are engaged in an organization the less is their common understanding. It stands to reason that what A knows is only partly shared by B, and if C joins the group there is still less that he shares with both A and B. Every added person decreases the measure of understanding common to all. But when the habit of working together is formed they can make their thoughts known one to another with little or no effort. A mere hint from A will illumine B and C, and under this joint illumination a new power arises. Our inhibitions are brushed away. We venture to propose things and to do things that theretofore we were too shy, too bashful, too lazy, too inert to propose. With this quality, resolution becomes contagious, and when every member of a laboratory staff is resolved to achieve a definite result and this resolution grows so strong that the quality of faith is added to it, then we are not indulging in idle vagaries when we hope for results. They come bounding along, provided, of course, those who constitute the staff are not idle dreamers.

Peace-Time Uses For Gas Bombs

EVERY time we read a press account of the riotous actions of leaderless mobs, men or women, we can't help thinking how salutary would be the effect of a little tear gas judiciously distributed. Mobs are hard to handle because they are without leaders and cannot be appealed to by reasonable means. The whole history of mob violence, in this or in other countries, shows how difficult it has been to handle them even when met by force or resort to violent means. Hitherto it has been necessary to call upon the police or the military, with resulting casualties that are deplored by even those in authority. But we now have a weapon that should be even more effective, not only because it will disperse mobs, but because one experience with tear gas is likely to be remembered for a long time and thus deter the potential mobber from engaging in that pastime again. The physical effect would only be temporary, but psychologically a dose of gas would have a beneficial and lasting influence. It seems to us that the time is ripe for the commercial exploitation of this method of controlling unruly citizens.

Engineers Honor Marshal Foch

IN CONFERRING upon Marshal FOCH honorary membership in the four national institutes of civil, electrical, mechanical and mining engineering, those bodies gave a fitting touch to the close of a strenuous visit to America by the recipient. Probably no guest from a foreign country has ever received more honors at the hands of his hosts, but it was particularly appropriate that the Marshal should have been recognized by engineers. As stated by Colonel PARSONS, commander of the Eleventh Engineers in France, in an introductory address, Marshal FOCH "directed a greater mass of human energy than any other man has ever done," and consequently had exhibited in the highest degree the qualities of an engineer, more particularly because he "successfully directed this mass for the highest uses of mankind." In acknowledging the honor bestowed upon him, the Marshal said that "it was due largely to the engineers and the engineering industries that the war was brought to a successful close," thus recognizing one of the most potent forces in the war, though perhaps it was and still is popularly the least recognized and appreciated. In honoring Marshal FOCH, the engineering societies honored themselves and gave a further impetus to the recognition of the importance of engineering.

Chemists and Time Clocks

WE REFERRED in our issue of Nov. 23 to the fact that in the Navy Department chemists are rated as artisans on a per diem basis. We have since learned that under a ruling made in September, on recommendation of a wage board consisting of a naval officer, a clerk from the office of the Secretary of the Navy and a representative of the American Federation of Labor, all technical employees and day laborers are now engaged on a per hour basis.

What is the use of this sort of tumblebug management? Why try to make head work look as much as possible like hand work? The man whose business it is to think must have freedom to think. We can all march in lock-step under compulsion—if we have our legs intact—but we can't think in lock-step and develop the thoughts and ideas that add to human progress and which are the things that are wanted of us.

We know one chemist who does his best work, thinks his best thoughts, while shaving in the morning. That, however, is no reason why "the shaving hour" should be made sacred to chemists or that the American Federation of Labor, which has nothing to do with the subject, should recommend time-and-a-half or double for the chemists' matutinal lathering and scraping. The chemist is a professional man. He may have remarkable manual dexterity or be singularly lacking in this respect and require laboratory assistants to do his work better than he can. What he is wanted for is his thinking, and he has had to develop his habits of thought in his own way. If he had not done this, he would not be wanted as a chemist.

The time clock is a useful invention to check off the work of men who predetermine their conditions of employment. In a laboratory, except for laboratory helpers, it is likely to be the most expensive piece of apparatus in the establishment. Thinking is not only work, but about the most difficult hunting of the present day is to find men who can and will think. Then why should we equip the position of a thinking man with hindrances which discourage thought?

We have great admiration for the honorable Secretary of the Navy as a man, but we wish he would read this. He can't pay much for chemists, and he needs them; needs good ones. Therefore he should not make such an absurd ruling no matter what a board of incompetent advisers may think. Often the whole issue between a positive and a negative result depends on whether the chemist at work on the problem takes a walk around the block by himself in the fresh air or not. There's too much unnecessary commanding and forbidding going on, and the cost of it is a halt to progress.

Chicago Chemists Show Progress

RECENTLY it was our good fortune to attend one of the regular meetings of the Chicago Section of the American Chemical Society, and we were struck with a plan of organization that seems to have worked successfully and which may be adapted to other large sections of the Society. Attendance at the monthly meetings of the Chicago Section has increased to such an extent that it became necessary to devise some means whereby a larger number of individuals could participate in the proceedings and particularly whereby the younger members could be encouraged to express themselves. At the suggestion of Dr. PAUL N. LEECH, chairman of the program committee, the Section adopted a plan of holding four group sessions following the principal program of the evening. Each month the majority of the members who attend the general session remain to participate in group meetings devoted to various phases and branches of chemistry. Here the everyday problems of the members of the groups are discussed freely and intimately. The whole scheme has been remarkably successful and is typical of the ingenuity and initiative that frequently characterize our Western friends. Precedent and formality are waived if they impede progress. The example is worthy of emulation in other sections where conditions warrant.

A Loss to the Cause Of Leather Chemistry

IN THE death of ARTHUR H. GALLUN, of Milwaukee, prominent in the manufacture of leather, the cause of chemical research in this industry has suffered a serious loss. With exceptional vision he supported vigorously the application of chemistry to the production of leather. For years he struggled to awaken in his fellow tanners a realization of the value and power of fundamental chemical research, but the time was not ripe and his preachments fell upon ears that refused to hear. Undaunted, he generously endowed research work at Columbia University, the results to be published freely so that the industry might see for itself the value of applied chemistry. With the same object in view, he inspired his own laboratories to contribute to the development of the science and assisted in the organization of the Leather Division of the American Chemical Society. At the time of his death he was trying to persuade the leather industry to establish at Columbia University a department of leather chemistry that should become second to none in the world. We regret his passing because the leather industry sorely needs the pioneer work he was doing so well. It will yet bear fruit, but not as soon as if he were here to give it his wise, far-seeing and energetic support.

American Institute of Chemical Engineers, Baltimore Meeting, December 6-9

Papers Presented at the Annual Winter Meeting Stress the Relation of the Chemical Engineer to the National Defense—Government Plants at Edgewood and Annapolis and Many Baltimore Chemical Industries Are Inspected—Election of Officers

BALTIMORE, during the four days Dec. 6-9, was the scene of the fourteenth annual meeting of the American Institute of Chemical Engineers. The many chemical industries of the vicinity and the close proximity to Edgewood Arsenal, the Naval Academy at Annapolis, and the Disarmament Conference in session at Washington served to give an appropriate background to the discussion of the theme of the meeting, which was "Chemical Engineering and the National Defense." An unusually large proportion of the Institute's membership was on hand to contribute to the symposium on this important subject and incidentally to enjoy the pleasant arrangements and entertainments provided by an enterprising local committee, headed by a very efficient local chairman, Albert E. Marshall.

During the first business session of the convention, which was called promptly to order on Dec. 6 by President David Wesson, many important items of the Institute's business were transacted. Following the reading of a number of reports by the secretary, Dr. John C. Olsen, and others, Dr. Arthur D. Little presented the final report of the committee on chemical engineering education. This committee has made a most comprehensive study of the courses offered by the universities and colleges of the country and has prepared a report which strongly emphasizes the need for reorganizing existing methods of instruction in chemical engineering. The report points out the extreme difficulty in obtaining comparable data in the seventy-three institutions which teach this subject. This was due not only to the extraordinary number of subjects included in the chemical engineering courses, but also to the divergence in the weighting of courses among the various universities. In referring to the 210 subjects being taught, the committee was of the opinion that more than half were unnecessary. For instance, it is somewhat difficult to justify 49 subdivisions of chemistry and 35 of mechanical engineering.

The committee tabulated fourteen recommendations and conclusions which were as follows:

(1) There is an undesirable multiplication of subjects included in the chemical engineering courses. (2) Wherever possible intricate subdivision of subjects should be avoided. (3) A thorough grounding in chemistry and physics is essential. (4) An effort should be made to standardize the naming of courses. (5) There

should be less divergence in weighting courses. (6) Instruction in civil engineering, sanitary engineering and electrical engineering (beyond the fundamentals) might well be omitted. (7) Specialization by industries is considered advisable in the usual 4-year curriculum. (8) Small institutions where locality and special conditions call for training in certain industries may, however, be considered as exceptions to this rule. (9) Poor English and inaccurate report writing are recognized as prominent points of weakness in most engineering graduates. (10) Sources of information should be studied during the student's senior year. (11) The course in chemical engineering should best follow three years' preparation in mathmatics, economics and the sciences. (12) The difficulties of chemical engineering as a profession should be emphasized. (13) Courses should be arranged to give a professional degree to chemical engineers completing satisfactory work in the industries. (14) The use of students as instructors, even in elementary courses, should be deprecated.

It was voted that the committee's report be printed immediately by the council and that later the Institute should arrange to devote a meeting to the consideration of this subject, in which meeting representatives of the educational institutions might participate.

Atmospheric Pollution

Prof. James R. Withrow presented the report of the committee on atmospheric pollution. He called particular attention to the notable work of Dr. P. J. O'Gara of the American Smelting & Refining Co., Salt Lake City, Utah, and stated that the committee had urged Dr. O'Gara to publish the results of his investigations at the earliest possible date. In view of the prospective publication of the results of this and other extensive smelter fume investigations, the committee recommended that the Institute adopt no program of research, but rather hold itself in readiness to cooperate with the chemical manufacturers' associations and others interested in legislation and other methods of regulating atmospheric pollution. It was further urged that all chemical manufacturers recognize the far-sighted policy of settling promptly and out of court all just claims and that they fight to the limit all unjust claims because of the far-reaching damage which may result from precedents accidentally established through erroneous court decisions.

Student Chapters and Announcement of New Officers

Prof. A. H. White reported for the committee on student chapters. He submitted an amendment to the constitution of the Institute which provided for establishing student chapters in universities of recognized standing. The proposed plan is somewhat similar to that of the American Society of Civil Engineers in that while the student branches are recognized, there is no provision for student membership. According to regular procedure the amendment is to be sent out to the members for their approval.

Under the program of stated business the proposal was made to change the society's name to "The Institute of Chemical Engineers," but following a very eloquent and patriotic appeal by C. Burrows Morey, it was unanimously voted to retain "American" in the Institute's name.

Hugh Kelsea Moore, in discussing the method of nominating officers, protested against the appointment of a nominating committee and suggested that the method outlined in the Institute's constitution should be followed in future elections. Prof. Ralph H. McKee then announced the result of the canvass of ballots for next year's officers, which was as follows: Henry Howard, president; Albert W. Smith, first vice-president; Hugh K. Moore, second vice-president; Harlan S. Miner, third

Photo by C. H. Brown, official photographer, Edgewood Arsenal

vice-president; John C. Olsen, secretary; F. W. Frerichs, treasurer; Charles F. McKenna, auditor. The new directors elected were William H. Bassett, Arthur C. Langmuir and Alfred H. White.

The only address to be given during the first session was by L. W. Wallace, executive secretary of the Federated American Engineering Societies, who spoke of the work this organization had done during the first year of its existence and then outlined some of the important activities which are being contemplated. He especially stressed the need for an organized campaign in behalf of the Patent Office. The deplorable conditions existing there are causing delays of serious consequence to industry.

Visits to Curtis Bay Industries and Edgewood Arsenal

During the afternoon an excursion was made to the chemical industries at Curtis Bay. The plant of the U. S. Industrial Alcohol Co. was inspected and the visitors witnessed the operation of stills which were producing 95 per cent alcohol at the rate of 60,000 gal. per day. At the plant of the Davison Chemical Co. experiments were shown with silica gel to demonstrate its use in the making of sulphuric acid and ice, in drying air for blast furnaces and in refining gasoline and petroleum distillates. On the return trip the chemical engineers stopped at the plant of the American Refractories Co., where special magnesite and chromite bricks were being manufactured.

Approximately two hundred members of the Institute and of the Maryland Section of the American Chemical Society arrived at Edgewood shortly after 10 a.m. Dec. 7. Special facilities had been provided for a thorough inspection of the laboratories and manufacturing plants of the Arsenal. Especial interest was manifested in the chlorine, phosgene and chlorpicrin plants as well as in the factory which is turning out a daily production of 100 gas masks of the latest approved type.

Brigadier-General Amos A. Fries, chief of Chemical Warfare Service, addressed the party at luncheon. He declared that an effort was being made to stampede the Disarmament Conference against chemical warfare. The proponents of this propaganda include a number of well-meaning sentimentalists and so-called peace advocates, but a considerable proportion of them are to be recognized as self-interested enemies of the chemical industry. Chemical warfare, said General Fries, is the natural means of defense of a scientific people and, he declared, causes less permanent disability than any other weapon of warfare. Quoting statistics from the Surgeon-General's office, he showed that but 27.3 per cent of the men admitted to the hospitals during the late war suffered from gas injuries alone, that deaths directly attributable to gas were only 2 per cent of the total fatalities, and furthermore that the man injured by gas had twelve times as many chances for recovery as the man whose wounds were caused by shells or high explosives.

After the address by General Fries the party was taken to the testing range, where a demonstration of various gases and smoke materials was staged. The visitors, among them a number of ladies, stood on a slight hill and to their left, behind a rise of ground, were the various implements of chemical warfare. The first to be demonstrated was the Livens projector, which was used to lay down a dense cloud of smoke caused by the bursting of titanium tetrachloride projectiles. Stokes mortars were fired next, the shells being loaded with phosphorus. As they burst down the field throwing bits of fire far out into the air, another huge smoke cloud was raised. Artillery firing of 75-mm. gas shells followed, in which an attempt was made to demonstrate the accuracy of this method. The toxic smoke candles and hand grenades containing gases gave the visitors an idea of some of the post-war developments in chemical warfare. The grenades, which were filled with tear gas, were thrown so that the gas would drift away from the crowd. Some one, however, tossed one to the windward and as the gas settled over the spectators, most of them, weeping copiously, hurried away from the scene.

Presidential Address

The symposium on Chemical Engineering and the National Defense was opened by President Wesson on the morning of Dec. 8. Prof. Alfred H. White, who had been prevented from delivering his address on "Explosives and Fertilizers" at the earlier meeting, briefly summarized the principal points in his paper. Because of the importance of the subject and its treatment by Prof. White, arrangements have been made to have the address published in its entirety in an early issue of Chemical & Metallurgical Engineering.

The presidential address of Dr. Wesson dealt with the Institute of Chemical Engineers and the national defense. In his opening remarks President Wesson said:

> In the selection of meeting places for the Institute during the past years an effort has been made to have papers presented which bear definitely on the industries visited. Thus at Savannah we had the industries of the South and the cotton oil industry in particular. In Canada we had the products of the forests and mines and the manufacture of paper stock. At the New Orleans and Louisiana meeting we had sugar, salt and sulphur. At Detroit the automobile engaged our attention, and now, assembled in Baltimore with its vast chemical industries, the proximity to Edgewood Arsenal and the Disarmament Conference, it seems that the proper keynote to our meeting should be "Chemical Engineering and National Defense."

The speaker then traced the development of warfare, particularly in relation to chemistry and the part which chemical engineering plays in the national defense. In this connection he pointed to the accomplishments of the Institute:

> A glance through our membership roll will show the parts which our members take and have taken in building up the many industries of our country and keeping them on a sound economic basis. A study of these varied industries will show that while developed fundamentally for the beneficent demands of peace, they have proved towers of strength in time of war.
>
> Founded as it was with high ideals based on a sound code of ethics, the Institute has developed slowly but surely along conservative lines. It has now outgrown its swaddling clothes and with a broad-minded interpretation of its membership rules has increased the number of its members to a point where it has become a body of considerable influence in technical, educational and national affairs. With all of the best minds of our profession co-operating to advance the industries of our country so that in its chemical resources it may be second to none, the Institute has a great field of usefulness before it, and will play a most important part in the national defense of the future.

The Importance of Research

A paper by Dr. Raymond F. Bacon on "The Future Warfare" and another by Maximilian Toch entitled "Chemistry and the Next War" served to show the future possibilities offered by the development of chemical warfare. Both speakers emphasized that these

developments would come only through intensive research. Dr. Bacon's statement was as follows:

> One of the greatest lessons of the war, which so far has gone almost unheeded, was that large-scale research can solve practically any problem. We had in Washington a research organization in which were gathered many of the best brains of the country. That research organization was able to solve every problem put up to it by those in command of the military forces. It showed that things which seemed to be impossible to do could be done and done in a rather short time by research backed by adequate resources of brain power and apparatus. The total cost of that organization, put together and run admittedly not at the highest efficiency in the stress of war time, was about two million dollars, and for this comparatively small sum no one could deny that results were obtained which did more toward winning the war than any two hundred million dollars spent in other ways.
>
> If this government would efficiently spend a few million dollars a year on war research, methods would surely be devised which would make us absolutely safe from attack without the necessity of maintaining such extensive army and navy organizations as at present.

Harrison E. Howe further stressed this important subject in his address on "Fundamental Research in Conservation and Defense."

"The warfare of the future," said Mr. Howe, "seems sure to be of a decidedly different character than that which was known previous to the World War. Those concerned with our defense in the future are pretty sure to think in terms of molecules, atomic structure and perhaps atomic energy, rather than in millions of men and fleets of battleships. Our most potent defense, therefore, lies in knowledge to be acquired only through continued research."

In concluding his paper the speaker summarized his argument with the statement that "a certain amount of waste can be eliminated in industry, natural resources can be conserved and broad national interests forwarded to a great extent by the proper application of our present chemical knowledge. Our full duty as chemists and chemical engineers cannot be done, however, unless we are able to engage upon programs of serious fundamental research."

The Key Position of the Chlorine Industry

Dr. Benjamin T. Brooks presented a well-prepared paper dealing with the chlorine industry as an essential factor in our national defense. The fact that this industry is not in a critical position, such as the dye and organic chemical industry, perhaps explains why there has been no organized publicity calling attention to its vital relation to the manufacture of toxic gases. He cited that the United States military program of Aug. 12, 1918, called for the daily production of 646 tons of gas, a predominating proportion of which was to be made from chlorine. Among the war-time uses for chlorine other than in the manufacture of gas, Dr. Brooks called attention to the production of bleaching powder for the manufacture of chloroform and for preparing the well-known Dakin solution and for sterilizing drinking water in the camp and in the field, and also the use of chlorine in manufacturing several of the best smoke-screen materials, tetrachloride of tin, titanium tetrachloride and silicon tetrachloride.

The chemical products made by Edgewood Arsenal and its affiliated plants consisted of phosgene, chlorpicrin, mustard gas, diphenylchlorarsine, brombenzylcyanide, chloracetophenone, "D.M." titanium tetrachloride and tin tetrachloride, all of which substances require chlorine in their manufacture.

WASHINGTON'S MONUMENT AT MT. VERNON PLACE, BALTIMORE

This was the first monument to be erected by any state to the memory of George Washington.

One factor in the situation, which is by no means the least important, has been the improvements in the methods of transporting liquid chlorine. In this connection the speaker said:

> The small cylinder, containing 100 to 150 lb. of liquid chlorine, with which you are all familiar, was developed in Germany, but the tank car, holding 15 tons, and the large drum, holding 1 ton, of liquid chlorine are American developments. The first 1-ton containers were made in 1910, but their first extensive use came during the war period, when these containers were employed for shipping liquid chlorine to France. A special form of tank car, carrying chlorine in these 1-ton containers, has been developed, this method of transportation having all of the advantages of a 15-ton tank car, is comparably safer, and since these drums are removable from the car, they render storage and handling of liquid chlorine in large quantities a very simple matter. Another factor in the increased production of liquid chlorine is probably the improved liquefying process, consisting in the entrainment of chlorine in a falling column of concentrated sulphuric acid, by which means it is compressed under the necessary pressure. This simple method was given to the government by the Mathieson Alkali Works through Colonel C. F. Vaughn, and subsequently has been installed in other industrial plants.

Some Preventable Losses in the Chemical Industry

John S. Spicer, chemical engineer for the Pennsylvania Department of Labor and Industry, in an interesting communication called attention to the serious drain on man power and the increasing losses caused by industrial accidents. Reports from approximately one thousand chemical plants in Pennsylvania show that during 1920 there were sixty-two fatalities and that during the first 9 months of the current year fifty-eight lives were lost in these same plants. In other words, the indications are that the chemical industry of Pennsylvania, in spite of the fact that the number of workers is less, will probably experience a large increase in the number of fatal accidents. As an indication of the direct monetary loss, it is of interest to know that the compensation which must be paid this year by the chemical manufacturers of Pennsylvania will amount to almost a third of a million dollars. Furthermore, it is estimated that these industrial accidents entail a loss of 36,000 man-days and thus prevent the manufacture of approximately two million dollars worth of chemical

products. Considering the fact that these figures represent the losses incurred in but a single state, it is obvious that the engineers must co-operate to make the chemical industry less dangerous to the employee and more profitable to the management.

Meeting at Johns Hopkins University

Following a pleasant afternoon spent in an inspection of the grounds and buildings of the Naval Academy at Annapolis, the chemical engineers returned to Baltimore for a joint meeting at Johns Hopkins University with the Maryland Section of the American Chemical Society. Dr. J. C. W. Frazer delivered a popular address on carbon monoxide and its oxidation at room temperatures by means of a catalyst. Although the army gas masks used during the late war did not provide adequate protection against this gas, there are a number of reasons why carbon monoxide is impractical as a poison gas. It is not nearly as toxic as most war gases, and because of its density it readily diffuses. It is therefore difficult to maintain a lethal concentration in the field. Its critical temperature is such that it cannot be liquefied, and hence is not easily transportable. However, carbon monoxide is produced by incomplete combustion both on the field and in the battleship and submarine and therefore adequate protection must be provided against it. One of the possible protective measures was the development of a catalyst which would oxidize carbon monoxide at room temperature with oxygen from the air. In order to serve satisfactorily in the canister of a gas mask, the reaction must proceed to completion in a fraction of a second.

Dr. Frazer outlined the work which has led to the development of a particularly efficient catalyst.[1] This material consists of an intimate mixture of extremely finely divided manganese dioxide and silver oxide, although it has been found practical to replace the silver oxide with copper oxide. The physical condition of the catalyst, its porosity and moisture content are factors greatly affecting its efficiency. When used in the canister it has been found desirable to place a layer of calcium chloride or similar drying material immediately ahead of the catalyst.

Prof. R. W. Wood gave an interesting address on "Ultra-Violet Light" and presented some remarkable experimental demonstrations. One of the most practical applications of ultra-violet light in warfare was the development of a signaling instrument using invisible rays which focused on a phosphorescent screen. The electric searchlight and reflector method which had previously been used was unsatisfactory because it was visible and therefore likely to attract enemy fire. The screen used in the instrument devised by Prof. Wood was coated with barium-platinum sulphide on which the rays of ultra-violet light produce a very noticeable green phosphorescence. Other military uses for the invisible "lights" were for guiding ships in convoys, for identifying airplanes which had been camouflaged to represent those of the enemy, and in detecting secret communications which had been written with invisible ink.

Final Business Session

The report of meeting of the council was discussed at the last business session of the convention during the morning of Dec. 9. The proposal of the Detroit members that the Institute establish local sections was not approved in its entirety, although the council recognized the right of such sections to exist informally as long as their actions were not binding to the Institute. Prof. Badger's communication pointing out the inadequacy of the present published sources of chemical engineering abstracts was referred to a committee consisting of Messrs. Badger and Howe.

A resolution calling attention of Congress to the critical position of the domestic organic chemical industry and urging that adequate protection be given this industry was introduced by Prof. Ralph H. McKee and was passed unanimously. A second resolution informing the American delegation to the Disarmament Conference, the advisory committee thereto and the members of Congress of the imperative necessity of maintaining our Chemical Warfare Service was presented by Dr. Raymond F. Bacon and unanimously adopted.

The name of Brigadier-General Amos A. Fries was proposed for honorary membership in the Institute and the council was instructed to present his name to the members for immediate consideration.

Robert M. Yerkes, chairman of the information service of the National Research Council, reported that the council has organized a free information service which is acting as a clearing house for scientific and engineering interests. The purpose of this informational bureau is to facilitate research in all of the natural sciences and in the application of their results, and to render available to all who are intelligently interested in science and its applications reliable information about methods of research, research results, etc. Chemical engineers are cordially invited to avail themselves of this aid as they have occasion.

New Products From Petroleum

Prof. J. H. James of Carnegie Institute of Technology read an original paper on the subject of "Some New Petroleum Products," starting with petroleum as the raw material. Dr. James has obtained a series of novel chemical products which appear to have a broad field of industrial application. The process used is essentially the vapor phase, catalytic oxidation of aliphatic hydrocarbons. Among the products thus obtained are certain oxygenated acids with resin-like properties which may perhaps be utilized as cheap varnish gums and paint film substitutes, an unsaponifiable oil which can be used in lubricating greases, and finally a new fuel which might be called an "oxidized kerosene." The methods of procedure and the yields obtained are given in Prof. James' paper, which is to appear in a subsequent issue of this magazine.

Uses of Lime and Glass in Chemical Industry

M. E. Holmes, manager of the chemical department, National Lime Association, presented a paper entitled "An Outline of the Uses of Lime." The importance of this material to the chemist and chemical engineer is not always recognized nor is it generally known that practically 60 per cent of the total output of lime is consumed in the chemical industries. Mr. Holmes' paper and chart showing the many uses of lime for construction, agricultural and chemical purposes will be published in an early number of Chemical & Metallurgical Engineering.

A. E. Marshall, consulting engineer, of Baltimore, outlined some recent developments in the use of glass as a construction material for the chemical industries.

[1] A paper describing the preparation of this catalyst and its properties is to appear in the September, 1921, number of the *Journal of the American Chemical Society*, the publication of which has been delayed by printers' strike.

The speaker stated that the idea of conveying warm glacial acetic acid through a distance of 100 ft. in 6-ft. lengths of 2½-in. glass tubes had occurred to him after observation of a somewhat similar use of glass in an English plant where hydrochloric acid was being made by the salt-cake process. He has since found that manufacturers in this country are equipped to make much larger glass pipes (up to 6 in.) and various other shapes so that there is a promising possibility of developing glass in plant construction, particularly in condensing, conveying and catalytic processes in which transparency is a real advantage. Discussion by Messrs. H. K. Moore, A. S. Cushman and others brought out many additional applications of glass in large-scale chemical processes.

Regenerative Evaporation

Prof. W. L. Badger presented an interesting review of the subject of regenerative evaporation. A brief abstract of his remarks follows:

> The idea of compressing the vapors from an evaporation to the point where they could be re-used for heating was first proposed in 1840. At that time the evaporation industries were not ready for such ideas. It was advanced again in 1872 and in 1882. The idea was then fully appreciated, but inadequate mechanical equipment prevented its adoption.
>
> Within the last decade much attention has been given to this question, a number of machines developed, and many patents taken out. There is a voluminous literature on this subject, but most of it is from those who are directly interested in one or another of the devices offered.
>
> That it is possible, by regenerative evaporation, to attain multiple effect efficiency in a single effect is the claim of most of these articles. This is perfectly true. However, the work necessary to compress a pound of steam from the pressure of the vapor space to that of the heating space is approximately proportional to the temperature range through which compression is effected. Hence to make the power consumption reasonable, it is necessary to choose a small working temperature drop. If the solution which is evaporated has an appreciable elevation of boiling point, the vapor must be compressed through the useful temperature range, plus this elevation. In many cases this useless work of compressing through the boiling point elevation will be greater than the useful work of compression through the working temperature range. Hence the working temperature drop must be less than 10 deg. C., and in some cases as low as 3 deg. C.
>
> In the case of a multiple effect evaporator, only in the first effect of a triple or quadruple effect will the temperature drop be small enough to permit the operation of a regenerator. In such a case the problem is very complicated and a general answer cannot be given. Each case has to be decided in the light of its own conditions, though there will be a large fraction of all the cases in which the regenerator will not prove economical.

Developments of Chemistry in France

The last speaker to be introduced by President Wesson was Prof. Cavalier, president of the University of Toulouse and professor of metallurgy in that institution. He gave an illustrated address on the development of chemistry in France, particularly in connection with the growth and progress in methods of instruction. The universities and colleges in France now have an annual enrollment of 400 to 500 students in chemistry, and a large proportion of these are being trained as chemical engineers.

During the afternoon the visitors were given an opportunity to visit Baltimore plants engaged in chemical and allied lines of manufacture. Special automobiles were provided and parties were conducted through the plants of the Baltimore Copper Works, Standard Oil Co., Maryland Glass Co., Emerson Drug Co., McCormick & Co., National Enameling & Stamping Co., and Baltimore Tin Decorating Co.

NIGHT VIEW OF BALTIMORE'S BUSINESS DISTRICT

Convention Banquet

The annual dinner at the Emerson Hotel, Friday evening, marked the formal closing of the Institute's meeting in Baltimore. The toastmaster was Albert E. Marshall and the after-dinner speakers included Major Atkinson, personal representative of Brigadier-General Fries, Dr. Charles L. Reese of Wilmington, Dr. W. B. D. Penniman and Henry F. Baker of Baltimore, Dr. C. B. Morey of Buffalo, the Institute's secretary, Dr. J. C. Olsen, the retiring president, David Wesson, and President-Elect Henry Howard. In outlining his policies on the problems confronting the Institute, Mr. Howard declared that he favored a revision of the qualifications for membership, which should not, however, in any way lower the high standards of the Institute. After definitely establishing these standards, an effort should be made to increase the Institute's membership until it included all properly qualified chemical engineers. President Howard expressed the hope that the Institute's cordial relations with other scientific and professional organizations might continue and urged the members to co-operate heartily with the American Chemical Society, but at the same time keep in mind the need for maintaining the Institute as an independent organization of American chemical engineers.

New Magnet Steel

The large amount of apparatus, particularly precision and measuring instruments, possessing permanent magnets, generally of small dimensions, necessitates the finding of a metal highly susceptible to the acquisition and retention of magnetic properties. An important steel from this point of view, called K.S., discovered by a Japanese, has the composition: Carbon, 0.4 to 0.8 per cent; cobalt, 30 to 40 per cent; chromium, 1.5 to 3 per cent; tungsten, 5 to 9 per cent. It is very brittle and very hard, and great care has to be exercised in its manufacture. Its characteristics are surprising; its coercive range is about three times that of the best tungsten steel; the area of the hysteresis curve is also three times as great; the remanent magnetism is relatively very high; lastly, shocks and prolonged heating have a negligible effect on the magnetization. In shock tests, a slight diminution in remanent magnetism was observed—6 per cent after 850 impacts by dropping from a height of 1 meter to a cement floor.—*The Ironmonger*, Oct. 22, 1921.

Some Business Aspects of the 1921 Revenue Act

By Robert Murray Haig*

AMONG the numerous changes made by the new tax bill signed by President Harding on Nov. 23, five stand out as of great importance from the point of view of the business man and the investor. These are:

(1) The abolition of the excess profits tax as of Jan. 1, 1922, coupled with an increase in the income tax on corporations at that time from 10 to 12½ per cent.

(2) The reduction in the surtax rates on individual incomes which comes into effect at the same time.

(3) The establishment, with the beginning of next year, of a new class of income to be known as capital gain, subject to a maximum rate of 12½ per cent.

(4) The broadening of the definition of the "closed transaction," effective for the current year, which makes possible many exchanges of property for property without subjecting the gain to taxation.

(5) The recognition, beginning this year, of a net loss from one year's operation as an offset against any profits which may accrue in the two following years.

The first two changes have been the subject of wide comment, but the other changes, being of a somewhat more technical character, have been less discussed and their significance is less fully appreciated.

New Class of "Capital Gains"

The most revolutionary section in the new act is section 206, which sets up a new division of income. After the first of next year money made by individuals by selling or exchanging property "held for profit or investment" is subject to a maximum rate of 12½ per cent, instead of the regular rates, which range as high as 58 per cent (normal plus surtaxes). This is hedged about by several restrictions. The individual may not take advantage of the permission to use the 12½ per cent rate unless he is willing to pay at least 12½ per cent on his other income as well. The property "held for profit or investment" must have been so held for more than two years and may not include property "held for the personal use or consumption of the taxpayer or his family," or property which properly is subject to inventory. It is not necessary, however, that the property be connected with his trade or business.

The reason for the adoption of some such section as this is plain, whatever one may think of the wisdom of choosing this particular method of meeting the situation. As everyone knows, many sales of property have been postponed or entirely blocked by the unwillingness of prospective sellers to take their profits when they would immediately become subject to heavy surtaxes. This, of course, handicapped business. The solution adopted was practically to wipe out the offensive surtaxes on profits from this class of transactions.

One anomalous result of the selection of this solution, however, is that under this new arrangement a dollar of profit made from property which has grown in value is taxed at the maximum only 12½c., whereas a dollar made otherwise may be taxed as much as 50c. For example, in the case of a bond bought at a discount and sold at a profit, every dollar of interest on the bond may pay a tax nearly five times as great as every dollar of appreciation in the value of the bond, a fact which is likely to effect profoundly future methods of corporate financing.

Much more could be said regarding the effects of this new section from the points of view of equity and of administration, but what is of particular interest here is to point out the very substantial relief granted by it to investors in property which appreciates in value.

The "Closed Transaction"

The advantage to the investor in property which is gaining in value, conferred by the section just described, is accentuated by the liberal provisions governing the "closed transaction." (Section 202.) This has long been a troublesome section of the field of income tax procedure. When one exchanges property for cash, no question arises. The transaction is "closed" and one accounts for his gain to the tax collector. But when one barters instead of sells, receiving other property instead of cash for his property, very serious questions arise. There are sometimes differences of opinion as to the value of the property received, which lead to disputes and litigation. The old law went so far as to say that, in the case of such trades, the property received was to be treated as cash "to the amount of its fair market value, if any" (with certain exceptions in the case of a corporate reorganization, 1918 law, section 202). The new law goes much further. It now states positively that no gain or loss on trades shall be recognized unless the property received on the trade "has a readily realizable market value." The phrase, "readily realizable," adds a new and liberalizing element.

Even more important, however, are the exceptions made to the general rule. Even though the property received has such a "readily realizable market value," one need not account for the gain in certain cases. This is one:

"When any such property held for investment or for productive use in trade or business (not including stock in trade or other property held primarily for sale) is exchanged for property of a like kind or use."

How the Treasury will interpret this section is, of course, as yet unknown, but it would be a very narrow interpretation which would exclude exchanges of bonds or real estate for real estate. In other words, so long as one "barters" or "trades" his property for other similar property instead of selling it for cash, he need not account for his gains to the Treasury for tax purposes. Even if he does sell for cash, as has been noted above, he is subject to a tax of only 12½ per cent.

Net Losses

With one minor exception included in the 1918 law, it has been the practice since the beginning of income taxation in this country to treat each year as a unit and to refuse to permit the fact that one has lost money this year to affect the amount of profits he must report the following year. Each accounting period has been carefully "insulated" from other accounting periods. This practice has worked much hardship and the new law breaks away from the old precedents by inserting a provision, effective for 1921 (section 204, with a restriction on mines), which permits a net loss suffered in one year to be offset against any net income in the two next succeeding years. In other words, losses may be used to blot off subsequent gains, but losses are "outlawed" for this purpose after the expiration of two years.

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Destructive Distillation of Mixtures of Oil and Coal

A Comparative Study of Destructive Distillation Experiments on Coal, Oil and Mixtures of the Two in the Form of an Amalgam—Yield of Distillation Products—Composition of Tars—Nature of Light Oils—Quality of Gas—Residues

BY JOSEPH D. DAVIS,* PALMER B. PLACE† AND G. S. SCOTT†

IN THE course of investigations into the properties of mixtures of oil and coal made by the Bureau of Mines in co-operation with the Trent Process Corporation, a comparative study was made of the behavior of these mixtures and their constituents on destructive distillation. Mixtures of a petroleum oil and bituminous coal were first distilled under carefully controlled conditions, and then charges of the same oil and coal were distilled separately under similar conditions.

The quantity and quality of the distillation products were determined and results were compared. This comparison furnished a basis for judging whether greater values in products can be obtained by distillation of oil and coal in mixtures than by their separate distillation. In making the mixtures, the method use by the Trent process in cleaning coal was followed. The paste or plastic emulsion of oil and coal obtained is called "amalgam."[1]

When finely pulverized wet coal is mixed with approximately one-third its weight of oil, and agitated with a large excess of water, the coal and oil agglomerate to form a paste or amalgam. A large portion of the extraneous ash originally in the coal remains suspended in the water, with which it can be decanted from the amalgam. If the latter is now thoroughly drained and kneaded after the manner of working butter, most of the excess water enclosed can be removed. This, in brief, constitutes the Trent process for cleaning coal.

The effectiveness of the process for cleaning coal has been studied[2] by the bureau, and the results of the study show, in general, a high ash reduction and good recovery of combustible from coals of medium and high rank. With coals of the lowest rank, such as lignites, the process is only moderately successful, owing to the difficulty attending the preparation of coherent amalgam. Oil losses to water and refuse are small, and apparently it would be practical to rotate the same oil in the cleaning process if some efficient method were devised for recovering it from the amalgam, so a distillation process naturally suggested itself.

The oil used in making amalgams may be recovered from them by distillation. If it is completely volatile below the decomposition temperature of the coal, recovery is good and neither oil nor coal is appreciably altered in the process. If, however, a heavy, high-boiling oil is used, good recovery cannot be obtained without destructive distillation, in which case the distillates will contain decomposition products of both coal and oil. Generally a rich gas is also obtained, and the tendency is toward the production of a better coke than would be obtained from the coal alone on account of the cementing power of the oil residue. Even non-coking bituminous coals, when destructively distilled in heavy oil amalgams, will yield coke of fair quality and at least as much oil as would be obtained by refining the oil separately. The oil distilled from such amalgams is, of course, mixed with tar from the coal. In this connection it is important to know how the distillation products from heavy oil amalgams compare, both in quantity and quality, with those obtainable from the same quantities of oil and coal distilled separately. Any appreciable loss sustained through distillation of the mixed materials would tend to limit the choice of oils used in the cleaning process to those of low boiling range; any gain realized should be obtained also with oil-coal mixtures other than Trent amalgams.

The experimental work described later concerned only one class of oil and one class of coal. It was designed to show, by destructive distillation of amalgams and their constituents under exactly the same conditions:

(1) The comparative quantities of oil, residue and gas yielded by amalgams and by like quantities of oil and coal distilled separately. (2) The comparative qualities of oil and gases obtained. (3) The extent of cracking brought about by virtue of pre-mixing.

Theoretical Considerations

The theory of destructive distillation has not been developed sufficiently to enable one to predict with confidence from theoretical considerations the effect on their distillation products of pre-mixing such materials as oil and coal, the chief reason for this being a lack of knowledge of the chemistry of destructive distillation in general. It is known, however, that the chemical reactions involved are very sensitive to slight changes in distillation conditions, such as temperature, pressure and heating rate. It is important, therefore, in making comparisons, as with the problem at hand, to maintain similar conditions for all comparative experiments.

Chemically, there seems to be no interaction of oil and coal during formation of amalgams, and it is doubtful whether there is interaction in the retort before decomposition begins. During decomposition one would not expect reaction between the decomposition products of oil and coal, but, owing to the relatively large volume of vapors from the mixture, one might well expect more primary distillation products from the coal than when distilled alone, and less cracking of the oil vapors. The effect, purely physical, of large vapor volume would be to withdraw the vapors rapidly from the hot zone of the retort, thus tending to prevent secondary decomposition. The mixture of oil and coal considered here is certainly quite different physically from a simple sum of three parts oil and seven parts coal.

Amalgam is, in effect, a physical reaction product

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[1]The term amalgam is used here in its broadest sense—that is, to designate an intimate mixture of materials.

[2]Perrott, G. St. J., and Kinney, S. P., "The Use of Oil in Cleaning Coal," CHEM. & MET. ENG., vol. 25, Aug. 3, 1921, p. 182.

obtained on adding oil to wet coal in the proper proportions, and what may be called the driving force in this reaction is surface tension. Oil wets the coal by preference, and water wets the mineral matter, and both must be held at the respective surfaces with appreciable force, depending on the extent of surface affected. Theoretically, the distances through which such forces act are of molecular dimensions; that is, the nearer the thickness of the liquid film approaches to the diameter of a molecule the greater the force with which the film is held. With each succeeding layer of liquid molecules, the force of attraction diminishes.

Nelson and Hulett[2] computed the amount of moisture in a film of molecular thickness spread over colloidal coal particles in 1 c.c. of the substance, and found approximtely 0.06 c.c., or over 5 per cent of the weight of the coal. This water is so condensed that it has practically no vapor pressure at room temperature. The coal is sensibly dry. The same writers show experimentally that some moisture is retained by the coal at temperatures as high as 230 deg. C. Since, in a mixture of coal, oil and water, the oil wets the coal preferentially, one must assume that the force attracting the oil film to the coal is greater than that attracting the water; and one would expect films of heavy oils, particularly those of vapor pressure lower than that of water, to be held by the coal up to temperatures at which it begins to decompose.

Indication of Magnitude of Surface Forces

The amount of oil held at the surface of coal particles in an amalgam is difficult to estimate, and there is no direct method for measuring the surface forces involved. The writers found, however, on subjecting a navy fuel oil amalgam to pressure in a hydraulic filter press, that at pressures up to 31,000 lb. per sq.in., 5 per cent of the oil was still retained in the residue. This residue contained only a trace of water, which could be removed by drying at 105 deg. C., although the coal contained originally about 1 per cent moisture removable at that temperature.

[2]Nelson, O. A., and Hulett, G. A., "The Moisture Content of Cereals," *J. Ind. Eng. Chem.*, vol. 12, No. 1, Jan. 1, 1920.

TABLE I. ANALYSIS OF MATERIALS USED

Proximate Analysis of Big Muddy Coal

	Per Cent
Moisture	5.78
Volatile matter	31.87
Fixed carbon	52.42
Ash	9.93
Total	100.00
Sulphur	1.28

Fractionation of the Oil

Temperature, Deg. C.	Per Cent Distilling (Volume)
130 to 225	1.1
225 to 250	4.8
250 to 275	14.3
275 to 300	20.1
300 to 325	21.7
325 to 350	30.9
Residue	5.8
Loss	2.0

Analysis of Fractions

Cut, Deg. C.	Acids, per Cent	Bases, per Cent	Unsaturates,* per Cent	Aromatics,* per Cent	Paraffines, per Cent	Sp. Gr.
130 to 250	1.4	0.0	4.3	17.1	77.2	0.820
250 to 275	1.0	0.0	4.0	7.0	88.0	0.833
275 to 300	4.0	0.0	4.0	13.0	79.0	0.841
300 to 325	0.0	0.0	8.0	8.0	84.0	0.849
325 to 350	...	...	...	....	....	0.872

* Oil soluble in 95 per cent H_2SO_4, gravity 1.84, is called here "unsaturates"; "aromatics" are those oils insoluble in 95 per cent H_2SO_4, but soluble in 37*N* H_2SO_4.

It might be argued that distillation of the surface oil in an amalgam is analogous to distillation under pressure, a condition known to favor cracking reactions and the production of light liquid products. As a matter of fact, however, mixtures distilled in this research did not consistently produce more light liquid products than the constituents, but more and richer gas was obtained, and the tars contained a higher percentage of pitch. Cracking reactions were, therefore, favored by pre-mixing the materials, but the tendency was toward the formation of gaseous products rather than condensable liquids, as in the case of oil cracking under pressure. Actually, considerably more oil is required to make a coherent amalgam than can be accounted for in a film a few molecules thick enclosing

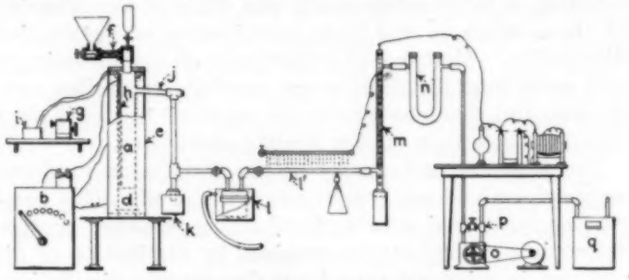

FIG. 1. COAL DISTILLATION APPARATUS

the coal, even if the individual coal particles are of colloidal size. Apparently, the distillation of this excess oil is not affected by the presence of the coal, and the total cracking effect observed in the distillation of the mixtures was due to the forces in the thin film.

The distillation of amalgams or mixtures containing large quantities of enclosed water results in the steam distillation of some of the heavy oils at temperatures below their normal boiling points. It is not believed, however, that steam has any appreciable effect on that portion of the oil in the molecular film enclosing the coal, since the vapor pressure of this oil must be very low. Further, parallel distillation tests made, wherein for one test the mixtures were made up dry, and for the other they were worked and air-dried to remove excess water, yielded approximately the same products. In other words, amalgams from which all excess water has been removed behave in the same way as dry mixtures on distillation.

Experimental Data

In order that the tests made at different temperatures in the distillation series of this paper be comparable, the same materials were used in all cases. The coal used was bituminous, and was obtained from the Big Muddy Coal & Iron Co., Herrin, Ill. The oil, a topped crude of asphaltic base, designated as navy fuel oil, was supplied by the Trent Process Corporation. Its specific gravity was 0.875 at 20 deg. C., and the viscosity 125 seconds Saybolt at 25 deg. C. The proximate analysis of the coal is given in Table I, together with fractionation results for the oil and an analysis of the oil fractions.

A sketch of the apparatus used is shown in Fig. 1. The retort *a* was made from a 48-in. length of heavy 6-in. iron pipe, which was insulated with asbestos paper and wound with nichrome wire for electric heating. The sheet metal casing *e* held a packing of infusorial earth for heat insulation. The top of the retort was provided with a hopper and worm *f* for uniform feeding of amalgam and coal; a 500-c.c. separatory funnel

served for feeding the oil. The distillation vapors and gases from the retort passed out through the pipe *j*, over the tar trap *k*, and into the water-cooled condensers *l* and *l'*, where most of the water and tar were condensed. A Cottrell precipitator *m* served to remove tar mists remaining in the gas, and the U-tube *n*, which was filled with gas-mask charcoal, retained light oils carried by the gas. A rotary pump *o* with an adjustable bypass *p* was used to keep a uniform pressure on the retort, and gas volumes were measured by the dry meter *q*.

Test Procedure

The distillation conditions for these tests approached those prevailing in the cracking of gas oil for the carburation of water gas. The object was a complete and rapid breaking up of the materials, as it was believed that by this treatment the cracking of oils and tars would be thorough; differences in cracking tendency of the materials would be exaggerated, and therefore easy to detect by analyzing the products. The method consisted in feeding the charges in small increments into the retort, previously heated to the temperature decided upon, this temperature being maintained as nearly constant as possible during the experiment.

Five series of tests were made, one at each of the temperatures 400, 500, 600, 700 and 800 deg. C. Each series included three distillations—one of the amalgam, one of the oil and one of the coal.

Amalgams were distilled first, and in each case a uniform rate of feed was maintained, which gave a fairly constant rate of gas volution. This was noted, and in subsequent distillations of oil and coal separately at the same temperature the feed was adjusted to give a similar rate of gas evolution. Thus the gases and vapors from amalgam, coal and oil, respectively, remained in the retort for the same period. No fixed weight of charge was predetermined. The runs were continued until it was judged that a sufficient quantity of distillation products had been collected for chemical examination. All parts of the condensing train were weighed before and after each run, and the adhering tars were removed as thoroughly as possible and mixed for analysis. Light oils caught in the charcoal absorber were analyzed separately.

On account of their complexity, analysis of the tars presented considerable difficulty. Methods for the analysis of petroleum were not strictly applicable, nor were those used in the analysis of coal tar. After considerable experimentation, the methods described by Weiss[4] for the analysis of coal tar were adopted, with slight modification. Briefly, the procedure was as follows:

A sample of 300 c.c. of the tar was dehydrated in a standard Barrett copper retort, fitted with a copper condensing trough, according to the method of Weiss, by heating continuously to 170 deg. C. The water distilling was collected in a 100-c.c. graduate, where its volume could be read directly. Any light oil distilling with the water was returned to the retort, after which the tar, now dry, was fractionated. Cuts were taken every 25 deg. All fractions boiling under 200 deg. C. were united, as were also those boiling between 200 and 350 deg. C., and the united fractions were analyzed for tar acids, tar bases, unsaturated compounds and paraffines.

The analysis was carried out in standard Barrett graduated separatory funnels, and consisted in washing the distillates successively with 10 per cent caustic soda for acids, 20 per cent H_2SO_4 for bases, 95 per cent H_2SO_4 (1.84 sp.gr.) for unsaturates, and 37*N* H_2SO_4 for aromatics. The contraction in the oil volume observed after repeated washings with the reagents represented the amount of the several constituents present. The residue unattacked by reagents represented paraffines. In this connection it must be observed that the washing test with 95 per cent H_2SO_4, although it was formerly depended on in the petroleum industry, has recently[5] been shown to give results of only approximate accuracy. This is particularly true with mixtures containing the higher olefines. However, since some idea of the amount of unsaturated compounds present in the distillates was highly desirable, and since this method was the only one available, it was used as giving approximate results and of value for comparison.

As would be expected from such a series of distillation tests on a small scale, the experimental error was rather large and an absolute interpretation cannot, therefore, be placed on the figures obtained. Their chief significance lies in their value for purposes of comparison, and the following general conclusions may be drawn:

(1) The amalgams at all temperatures yield less resi-

[4] Weiss, J. M., "Methods of Analysis Used in the Coal-Tar Industry," *J. Ind. Eng. Chem.*, vol. 10, No. 9, p. 732; vol. 10, No. 10, p. 817; vol. 10, No. 11, p. 911; vol. 10, No. 12, p. 1006.

[5] Brooks, B. T., and Humphrey, Irwin, "The Action of Concentrated Sulphuric Acid on Olefines, With Particular Reference to the Refining of Petroleum Distillates," *J. Am. Chem. Soc.*, vol. 40, No. 5, p. 822.

TABLE II. FIELD OF DISTILLATION PRODUCTS

Test No.	Charge	Temp. Deg. C.	Run—Kind	Yields, per Cent of Charge: Residue	Tar	Gas	Light Oils: Gas	Light Oils: Tar	Yields, per Ton Charge: Residue Lb.	Tar, Gal.	Gas, Cu. Ft.	Light Oils: Gas, Gal.	Light Oils: Tar, Gal.	Light Oils, Total	Remarks
9	Amalgam..	400	Continuous..	57.7	14.1	2.5	0.12	(1.9)	1,154	33.7	750	0.38	4.6	....	Charge 30% oil, 70% coal
14	Coal.....	400	Continuous.	75.7	2.5	3.3	0.51	(0.26)	1,514	6.0	980	1.5	0.9	....	
21	Oil.....	400	Continuous.	67.8	30.0	2.2	....	(2.9)	1,356	71.8	600	....	9.2	....	
	Sum.....			73.3	10.8	3.0	....	(1.05)	1,467	25.7	866	....	3.4	....	
11	Amalgam..	500	Continuous.	54.9	12.5	11.2	0.97	(0.93)	1,089	29.9	4,470	3.0	6.2	9.2	Charge 30% oil, 70% coal
18	Coal.....	500	Continuous.	70.9	2.0	9.1	0.12	(0.15)	1,448	4.8	2,970	0.4	0.5	0.9	
24	Oil.....	500	Continuous.	24.9	51.4	17.9	1.10	(5.3)	498	123.0	5,300	3.1	16.9	20.0	
	Sum.....			57.1	16.8	11.7	0.57	(1.7)	1,143	40.4	3,670	1.1	5.4	6.5	
20	Amalgam..	600	Continuous..	45.7	19.0	23.6	2.70	(1.63)	914	45.5	10,650	7.2	6.3	13.5	Charge 30% oil, 70% coa
19	Amalgam..	600	Batch.....	52.2	20.0	13.8	1.50	(2.00)	1,044	47.8	5,650	3.7	7.2	....	Charge 30% oil, 70% coal
17	Coal.....	600	Continuous.	63.7	12.7	19.7	1.70	(2.1)	1,274	30.4	6,430	4.6	7.3	11.9	
23	Oil.....	600	Continuous.	13.3	30.9	51.2	4.00	(5.14)	266	74.0	16,900	11.1	17.4	28.5	
	Sum.....			48.6	18.2	29.1	2.40	3.0	972	43.5	9,570	6.5	10.3	16.8	
30	Amalgam..	700	Continuous.	47.9	13.7	23.0	2.80	(1.0)	958	44.4	10.100	6.7	1.8	8 5	Charge 30% oil, 70% coal
26	Coal.....	700	Continuous.	62.8	4.5	24.4	0.75	(0.29)	1,256	10.8	10,750	2.1	0.8	2.9	
22	Oil.....	700	Continuous.	19.8	27.2	49.5	2.60	(4.3)	396	65.0	19,320	7.0	12.7	19.7	
	Sum.....			49.9	11.3	32.0	1.30	1.5	999	27.1	13,320	3.5	4.4	7.9	
6*	Amalgam..	800	Continuous.	51.7	13.1	23.2	1.90	....	1,034	....	19,800	4.1	....	....	Charge 25% oil, 75% coal
7*	Coal.....	800	Continuous.	72.0	4.0	19.1	0.23	....	1,440	....	10,000	0.55	....	....	
8*	Oil.....	800	Continuous.	50.6	9.3	39.2	0.87	....	1,012	....	20,050	2.1	....	....	
4	Amalgam..	800	Batch.....	53.7	24.4	5.4	0.59	(1.15)	1,074	58.4	3,400	1.7	5.2	....	Charge 25% oil, 75% coal
	Sum.....			66.6	5.3	24.1	0.40	....	1,333	....	12,630	1.0	....	....	

* Results for residue and tar uncertain, fixed carbon carried over from retort into tar trap.

due than would be obtained by distillation of their constituents separately.

(2) The amalgams yield a greater quantity of tar than their constituents except at 500 deg. C., where conditions favor the complete distillation of the oil without excessive cracking into gas.

(3) The amalgams yield a larger volume of gas than

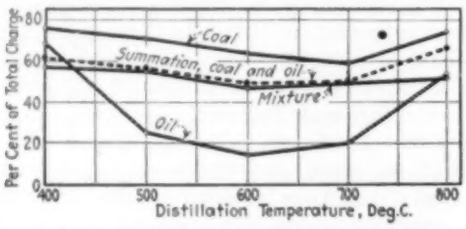

FIG. 2. RESIDUE VARIATION WITH TEMPERATURE

the constituents as a rule, and incidentally it has uniformly a higher heating value than that from constituents (see Table IV), but its specific gravity is lower.

(4) The total light oil yield is usually greater for the amalgams. The difference in yield, however, is small, perhaps within the limit of experimental error.

(5) At 800 deg. all tars are almost completely cracked into gases and fixed carbon.

Table II gives the yield figures for all distillation tests of amalgam, coal, oil, and the sum. This last item was calculated from the separate distillations of coal and oil, and represents what would be obtained by distilling 30 parts of oil and 70 parts of coal separately, and combining the products. The graphs in Figs. 2, 3, 4 and 5 show the variation in yield of the products,

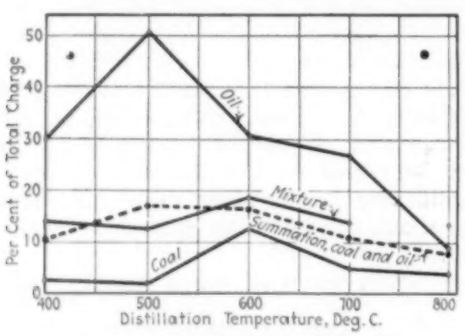

FIG. 3. TAR YIELD VARIATION WITH TEMPERATURE

residue, total oil, light oils and gas respectively, with temperature.

In the case of batch distillations of amalgam included in Table II for temperatures 600 and 800 deg. C., the total charge was placed in the cold retort and heated gradually to distillation temperature. At both temperatures there was a much larger yield of gas by the continuous method, the high yield apparently being at the expense of the residue at 600 deg. C., and at the expense of the tar at 800 deg. C.

Comparing the behavior of the amalgam with that of its constituents on distillation, as shown by the quality of the tars (Fig. 6), it is clear that it is the more sensitive to temperature. At 400 deg. C. the distillation residue is practically the same as that calculated for the sum of its constituents, but with higher distillation temperatures it becomes much greater than that for the sum. A higher percentage of pitch carbon in the amalgam tars is indicated, and hence a more extensive cracking with rising temperature. Corresponding to this, one might expect an increase of unsaturates and aromatics in the amalgam tars, but as a matter of fact these tars contain less aromatics and unsaturates at the higher temperatures than that calculated for them. The products of the cracking must therefore be found in the gas, and, as previously shown, this is borne out by a higher yield of richer gas for the amalgams.

As would be expected, the paraffine content of the tars drops rapidly with rising temperature for all continuous distillations to practically zero at 70 deg. The paraffine content of the amalgam tars is lower than the calculated values for all distillation temperatures except 400 deg. C. This is further evidence of the more complete thermal decomposition of amalgam tars.

In general, the oils known to be largely composed of paraffines originally react in the same way as the coal under the influence of heat. The constituents of

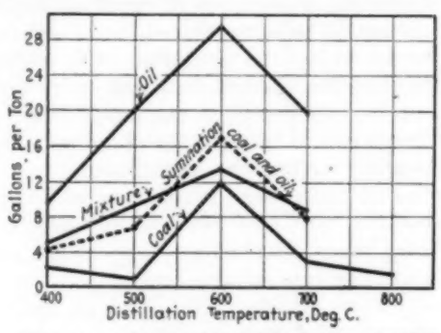

FIG. 4. TOTAL OILS BOILING UNDER 200 DEG. C.

the tars vary similarly with rising temperature. Neglecting compounds that produce phenols, it can be argued that the volatile constituents of coal are largely of a paraffine nature.[6]

Table III gives the composition of the tars, and Figs. 6, 7, 8 and 9 show the variation in tar quality with temperature.

Tars from batch distillations at 600 and 800 deg. C., wherever the whole amalgam charge was placed in the cold retort and heated gradually to the distillation temperature, show much less thermal decomposition than tars obtained by the continuous method. The paraffine content even at 800 deg. was 41 and 65.8 per cent; whereas the tars from the continuous method were so broken up that analysis was impractical. Actually, most of the tar from the batch distillation came off at much lower temperatures than 800 deg. C.—that is, during

[6]Whitaker, M. C., and Suydam, J. R., "A Comparative Study of the Thermal Decomposition of Coal and Some of Its Products of Carbonization," *J. Ind. Eng. Chem.*, vol. 10, 1918, p. 431.

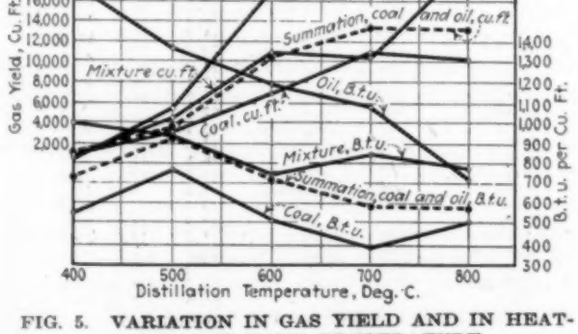

FIG. 5. VARIATION IN GAS YIELD AND IN HEATING VALUE WITH TEMPERATURE

TABLE III. COMPOSITION OF TAR

Test No.	Charge	Temp., Deg. C.	Run, Kind	First Drop at Deg. C.	Boiling 0-200 Deg. Per Cent	Boiling 0-200 Deg. Sp.Gr. 15 Deg. C.	Boiling 200-350 Deg. Per Cent	Boiling 200-350 Deg. Sp.Gr. 15 Deg. C.	Residue, per Cent	Fractions 0-200 Deg., per Cent — Acids	Bases	Unsaturates	Aromatics	Paraffines	Fractions 200-350 Deg., per Cent — Acids	Bases	Unsaturates	Aromatics	Paraffines
9	Amalgam	400	Continuous	..	13.77	0.822	72.83	0.879	13.40	7.0	1.0	44.0	19.0	29.0	4.5	1.0	21.5	19.3	53.7
14	Coal	400	Continuous	85	15.20	0.890	26.80*	0.956	58.00	32.0	2.9	36.0	22.0	7.1	46.4	1.4	37.9	11.4	2.9
21	Oil	400	Continuous	60	12.92	0.759	77.29	0.832	9.79	2.2	1.1	35.6	22.2	38.9	1.30	0.30	14.00	18.30	66.10
	Navy fuel oil, analysis 150 deg.				1.33	0.820	93.07	0.848	5.60	....	....	....	....	....	....	....	....	....	....
11	Amalgam	500	Continuous	65	20.66	0.951	37.50	0.970	41.84	11.4	4.3	63.0	21.3	0.0	2.7	5.4	54.0	20.0	17.9
13	Coal	500	Continuous	90	9.66	0.933	41.30*	.....	49.04	28.8	4.0	40.0	18.0	10.0	....	....	....	....	....
24	Oil	500	Continuous	..	13.79	0.864	62.37	0.886	23.84	2.6	3.1	47.1	31.4	15.8	1.4	0.7	28.4	25.2	44.3
20	Amalgam	600	Continuous	80	13.90	0.890	17.80*	0.980	68.30	9.7	4.6	84.5	2.2	0.0	7.5	5.0	65.0	22.5	0.0
19	Amalgam	600	Batch	80	15.14	0.845	68.79	0.865	16.07	13.2	2.2	29.4	24.1	31.1	6.13	1.5	16.6	11.84	63.73
17	Coal	600	Continuous	90	22.90	0.945	32.50	1.000	43.60	32.3	3.1	64.6	0.0	0.0	46.4	2.3	51.3	0.0	0.0
23	Oil	600	Continuous	50	23.57	0.899	57.25	0.980	19.18	0.0	0.0	60.0	38.0	7.0	0.0	0.0	60.0	20.0	20.0
30	Amalgam	700	Continuous	85	5.4	.....	8.1	.....	86.50	8.0	0.0	92.0	0.0	0.0	0.0	1.0	31.0	53.5	14.5
28	Coal	700	Continuous	80	7.4	0.910	24.3	0.960	68.30	22.2	2.3	75.5	0.0	0.0	13.7	4.5	42.2	30.3	9.3
22	Oil	700	Continuous	70	19.5	0.898	54.4	0.962	26.10	0.5	0.0	58.0	41.5	0.0	0.5	0.0	41.0	58.5	0.0
6	Amalgam	800	Continuous†	†	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Amalgam	800	Batch	..	8.90	0.850	54.87	0.857	35.23	13.0	2.0	26.0	18.0	41.0	3.8	1.2	11.2	18.6	65.8
7	Coal	800	Continuous	..	4.5	.....	28.9($C_{10}H_8$ 10.9%)		66.6	....	...	....	....	....	....	...	....	....	....
8	Oil	800	Continuous	†	.....	.....	.....	.....	.....	....	...	....	....	....	....	...	....	....	....

* Boiling 200–300 deg. C. † Tar consisted of heavy hydrocarbons and fixed carbon, regular analysis impractical.

the gradual heating to that temperature. By feeding the charge continuously in small increments, it was all heated almost instantaneously to the highest distillation temperature, and distillation took place, to borrow an expression from steam boiler technology, "from and at" that temperature.

Light oils absorbed by passing the gas through gas-mask charcoal consisted almost entirely of unsaturates

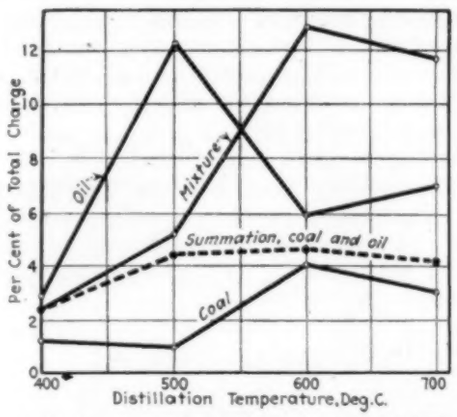

FIG. 6. TAR DISTILLATION RESIDUES

and aromatics, except where amalgams were distilled in batch and where the coal was distilled at 400 deg. C. Appreciable quantities of paraffines were here present. Eighty to 90 per cent of the oils extracted by the continuous distillation method were volatile under 100 deg. C., and practically all of them were completely volatile under 125 deg. C. The light oil from the coal distillation at 400 deg. C. was not completely distilled until a temperature of 200 deg. C. was reached, and then a tarry residue amounting to 5 per cent of the oil remained. The presence of condensable compounds, such as indene and cumarone, is thus indicated.

Several samples of gas were taken at corresponding time intervals during each distillation test, and the analyses of these grab samples were averaged. All samples were taken after the gas had passed the light oil scrubber, and their heating value was therefore lower than that of the raw gas.

For the most part, the gas yielded by the amalgams was better than that calculated for them from the gases obtained from the oil and coal; its volume also was greater. The weight per cent yield of amalgam gas was low (see Table II) chiefly owing to a low CO_2 content. Its illuminant content was high, which fact partly accounts for its high heating value. Further, it contained more methane and less carbon monoxide than the calculated gas. Table IV gives average analyses of gases from all test runs of the series, together with an analysis of amalgam gas for each temperature calculated from the gas yields of oil and coal.

The total heating value of the amalgam gas is superior to that obtained from its constituents distilled alone, as the following approximate calculation shows:

	Distillation Temp., Deg. C.	B.t.u. per Cu.Ft.	Cu.Ft. per Ton	B.t.u. in Gas From 1-Ton Charge
Amalgam	400	1,000	750	750,000
Calculated	400	739	866	640,000
Amalgam	500	937	4,470	4,188,000
Calculated	500	951	3,670	3,492,000
Amalgam	600	730	10,850	7,920,000
Calculated	600	717	9,570	6,860,000
Amalgam	700	832	10,100	8,408,000
Calculated	700	576	13,320	7,670,000
Amalgam	800	757	19,800	14,980,000
Calculated	800	560	12,630	7,070,000
Oil alone	800	710	20,050	14,450,000

Owing to the relatively small scale on which the experiments were made, and the consequent large experimental error, the above figures can not be considered as absolute; they do show, however, comparative gas

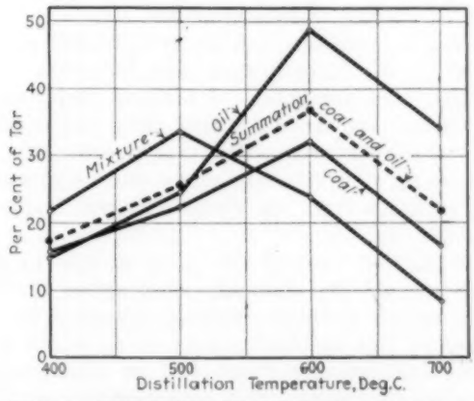

FIG. 7. PERCENTAGE OF TOTAL UNSATURATED BODIES IN TAR

values obtained in distilling oil and coal. At every temperature the advantage of amalgam gas is consistent. Apparently, a bituminous coal amalgam of such coal and oil as used here should be applicable

TABLE IV. ANALYSES OF GASES FROM TRENT AMALGAMS, COAL AND OIL

Charge	Temp., Deg. C.	CO_2	C_2H_4	O_2	CO	CH_4	C_2H_6	H_2	N_2	B.t.u. per Cu. Ft. Calculated	Yield Cu.Ft. per Ton	Oil From Gas, Gal. per Ton	Remarks
Amalgam	400	9.8	23.4	0.6	4.0	29.1	17.3	8.9	6.9	1,000	750	0.38	Oil 30%; coal 70%.
Coal	400	17.9	0.5	0.4	11.7	46.7	0.0	17.4	5.4	550	980	1.5	
Oil	400	15.5	16.6	0.0	1.0	23.2	39.1	4.6	0.0	1,182	600	0.0	
Sum	...	16.7	5.5	0.3	8.6	33.7	11.8	13.6	3.8	739	866	....	
Amalgam	500	3.0	17.0	0.0	5.3	37.4	12.0	25.0	0.3	927	4,470	3.0	Oil 30%; coal 70%
Coal	500	10.2	1.2	0.6	19.7	38.4	8.5	12.2	8.6	779	2,970	0.4	
Oil	500	0.6	39.6	0.4	0.5	29.3	24.1	2.9	2.6	1,353	5,300	3.1	
Sum	...	7.4	12.6	0.5	14.1	35.8	13.1	9.5	6.9	951	3,670	....	
Amalgam	600	3.0	8.8	0.6	8.7	50.8	0.0	25.3	2.8	730	10,850	7.2	Continuous feed oil 30%; coal 70%.
Amalgam	600	3.3	13.6	0.6	7.5	48.4	0.0	23.9	1.7	794	5,650	3.7	Batch distillation.
Coal	600	4.7	3.3	0.5	11.4	30.6	0.0	46.2	3.3	525	6,430	4.6	
Oil	600	1.8	31.0	0.5	1.8	46.3	10.8	5.0	2.8	1,167	16,900	11.1	
Sum	...	3.8	11.6	0.5	8.5	35.4	3.2	33.9	3.1	717	9,570	....	
Amalgam	700	2.6	13.9	0.1	6.9	46.9	3.2	25.3	0.3	832	10,100	6.7	Gas samples uncertain; oil 30%; coal 70%
Coal	700	6.4	0.6	0.5	28.1	13.0	0.0	46.9	4.5	376	10,750	2.1	
Oil	700	0.4	23.2	0.5	0.5	63.6	2.0	8.3	1.5	1,056	19,320	7.0	
Sum	...	4.6	7.4	0.5	19.9	28.2	0.6	35.3	3.5	576	13,320	....	
Amalgam	800	4.9	8.9	0.7	6.7	35.3	8.1	31.5	3.9	757	19,800	4.1	Continuous feed; oil 25%; coal 75%.
Amalgam	800	4.7	6.1	0.0	7.9	32.9	5.4	36.9	3.4	654	3,400	1.7	Batch distillation.
Coal	800	4.2	3.0	0.4	16.5	26.6	0.0	45.4	3.9	496	10,000	0.55	
Oil	800	2.1	2.2	0.0	1.6	63.7	0.0	28.2	2.3	710	20,050	2.1	
Sum	...	3.5	2.8	0.3	12.0	37.7	0.0	40.3	3.4	560	12,630	....	

in the carburation of water gas, if a method were devised for handling the residues produced.

In no case where the continuous distillation method was employed was the residue coked. It was in the form of a fine powder, there being little tendency to

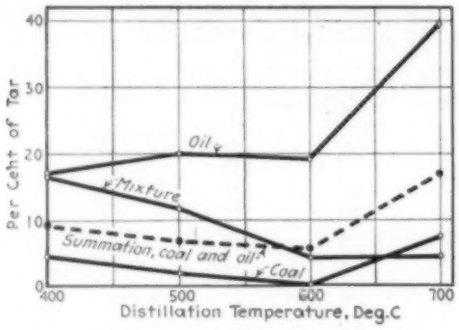

FIG. 8. TOTAL AROMATICS IN TAR

fusion, and contained at the higher temperatures a considerable quantity of finely divided carbon, a product of tar cracking reactions. Batch distillations of amalgams yielded a fairly coherent coke, but apparently no better than that from the coal alone.

CONCLUSIONS

Oil and coal were distilled under carefully controlled conditions at the temperatures 400, 500, 600, 700 and 800 deg. C., and amalgams of oil and coal were then distilled under similar conditions, and the distillation products were compared. For this purpose, the yields to be expected for the amalgams were calculated at each temperature from the yields obtained from the oil and coal distilled alone.

The distillation method used was unique in that it aimed at a rapid and complete destructive distillation of the materials within a narrow temperature range. The effect of this method was to bring about a more rapid thermal decomposition, and at lower apparent temperatures than is the rule in destructive distillation practice. The conditions of distillation were very similar to those prevailing in the carburation of water gas.

Comparison of the products shows in general that different results are obtained by distilling amalgams or mixtures of oil and coal from those obtained by distilling the constituents separately. Consistent differences appear in the quantity of residues obtained, and in the quantity and quality of the gases. Differences in the tar products are not so well defined. Light oils extracted vary in quantity and quality, but probably within the limits of experimental error. The results show that for this distillation method:

(1) Amalgams are more sensitive to temperature than their constituents. This is probably due to the fact that in the amalgams a part of the oil is held by surface tension forces in contact with the coal at temperatures above its boiling point.

(2) Amalgams yield a smaller distillation residue than their constituents, and a larger volume of gas.

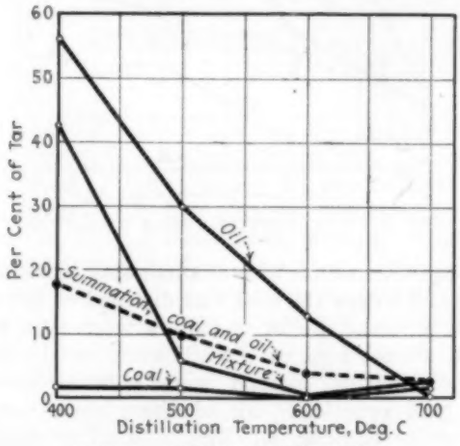

FIG. 9. TOTAL PARAFFINE CONTENT IN TAR

Further, the quality of this gas is better than the combined gases from coal and oil.

(3) Amalgams do not give a better light oil yield than their constituents, but they give a higher yield of tar, which is of poorer quality, containing excessive quantities of pitch.

ACKNOWLEDGMENTS

The authors wish to acknowledge their indebtedness to A. C. Fieldner, supervising chemist; G. St. J. Perrott, physical chemist; R. L. Brown, associate organic chemist, and E. W. Dean, petroleum chemist, of the U. S. Bureau of Mines, Pittsburgh Experiment Station, for many helpful suggestions in this work.

Boiling Point of Salt Solutions Under Varying Pressures*

Derivation of a General Law Which Greatly Simplifies the Accurate Determination of Important Data on the Boiling Points, Over the Usual Range of Pressure and Concentration, of Salt Solutions Commonly Evaporated in Vacuum Evaporators

BY E. M. BAKER AND V. H. WAITE

IN AN EARLIER paper[1] attention was called to the fact that in the design of an evaporator installation it is necessary to know the elevation of the boiling point of the solution being evaporated in each effect, at the temperature and pressure existing in that effect. It was further pointed out that while the literature shows a large number of determinations of the elevation of boiling points of aqueous solutions, many of these determinations were made at comparatively early dates with crude apparatus, and hence there frequently were wide variations in the values reported. This laboratory announced the intention of proceeding with the determination of the vapor pressure curves of such solutions as are used by the chemical industry and are commonly concentrated in vacuum evaporators. The Division of Chemistry and Chemical Technology of the National Research Council became interested in this work and made it one of its supported projects. The Council desired that the work be carried out to a greater degree of accuracy than was determined for technical purposes, in order that the data obtained might have a higher value for use in purely theoretical studies. To meet this condition, it was necessary to develop an apparatus in which the pressure could be maintained practically constant and in which other sources of error might be kept below a fixed maximum. The limit considered permissible for this work was placed at an absolute error of 0.1 deg. C.

DESCRIPTION OF APPARATUS

A sketch, partly diagrammatic, of the apparatus used is shown in Fig. 1. The solution whose vapor pressure was to be determined at different temperatures was placed in the glass tube *I* and then heated by an electric current passing through resistance coils in the heater *C*. The current was regulated by an external resistance and the current and voltage used were read on suitable meters. A modified Cottrell[2] pumping tube *D* was slipped down over the heater and used for pumping a mixture of the solution and vapor over the platinum resistance thermometer *B*. The tube *I* was jacketed with a second glass tube, *E*, to minimize the effect of air currents. The vapors coming from the boiling solution passed into a condenser *G*, to which is connected a large glass reservoir *H*. From *H* a line of glass tubing leads to a small catch bottle *J*, connected to a laboratory water-jet vacuum pump. This catch bottle was also connected to a vacuum regulator, consisting of two parts, a manometer *M* and a needle valve operated by the solenoid *K*. An increase in the vacuum over the value desired would cause the mercury to rise in the manometer and in turn make a contact with the platinum tipped rod *F*, and complete a low-voltage circuit through the mercury and the relay *R*. This caused the relay to complete a 220-volt direct-current circuit through the solenoid *K*, thus pulling up its armature. The lower end of this armature constituted the plug of the needle valve.

It is necessary to be able to regulate the lift of the needle valve since different openings are required for

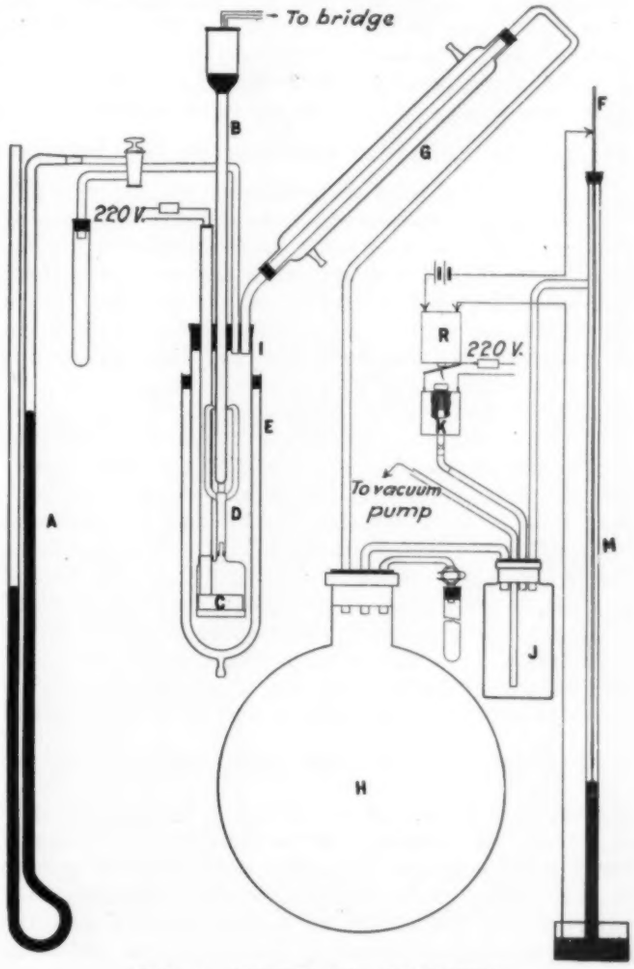

FIG. 1. SKETCH OF APPARATUS

best regulation at different absolute pressures. This regulation is obtained by screwing the upper end of the solenoid core up or down to the required position. By a proper setting of the pump the vacuum is regulated to a value slightly in excess of that wanted, and the "vacuum regulator" used to give the vacuum desired. The mercury in the regulating manometer oscil-

*Read before the thirteenth semi-annual meeting of the American Institute of Chemical Engineers, at Ann Arbor, Mich., June 21, 1921.

[1] "The Boiling Point of Salt Solutions," by W. L. Badger and E. M. Baker, *Trans.* Am. Inst. Chem Engrs., 1920, also CHEM. & MET. ENG., vol. 23, No. 12, pp. 569-574, Sept. 22, 1920.

[2] *J. Am. Chem. Soc.*, vol. 41, pp. 721-9 (1919).

lates regularly up and down, the magnitude of the oscillations being about 3 mm. The reservoir or vessel of large capacity *H* served to damp these oscillations, and to maintain the vacuum in the boiling point apparatus at a very constant value. This vacuum was measured by a manometer *A* connected directly into the boiling-point tube, thus insuring that the pressure read was the true pressure under which the liquid was boiling. The manometer was made of 10-mm. glass tubing in order to minimize the effect of capillary action. The variations in pressure in the boiling-point tube were so slight that the bottom of the mercury meniscus in the measuring manometer would show no perceptible movement over periods as long as a half hour, but the center of the meniscus would breathe or oscillate regularly up and down a distance of 0.1 to 0.3 mm. This measuring manometer was mounted against a mirror to aid in eliminating the parallax in reading. The value of the manometer reading was taken by a steel rule graduated in half millimeters and mounted so that it could be racked up and down over the manometer. In making a pressure reading, the rule was adjusted so that its bottom edge was just level with the center of the mercury meniscus in the low arm, and the graduated edge of the rule came to the center line of the mercury in the high arm. The reading of the center of the meniscus in the high arm was taken with the aid of a magnifying glass, care being used to avoid errors of parallax.

Methods of Measuring Temperature and Pressure

A 10-mm. tube filled with mercury was hung beside the measuring manometer, and its temperature read on a mercury thermometer whose bulb extended some distance down in this mercury. The temperature so read was taken as the temperature of the mercury in the measuring manometer. By this means the effect of lag with changing room temperatures was eliminated.

The temperature of the boiling solution was taken by a platinum resistance thermometer *B*. Except where otherwise noted, this thermometer was not immersed in the body of the liquid, but was in the vapor space. The thermometer tube was kept well wetted with solution for a distance about an inch above the platinum coil by means of the pumping tube *D*. The resistance thermometer was constructed according to the method as given by the Bureau of Standards,[3] and was provided with compensating leads. The resistance was measured by means of a bridge with a wall galvanometer. In calibrating the thermometer and at all other times, the resistances corresponding to *A* and *B* in the formula $X = \frac{A}{B} R$ were each 1,000 ohms, and the same resistance coils were used for *A* and *B* throughout. For adjusting the resistance *R* to balance *X* a precision resistance was placed in parallel with the resistance *R* of the bridge proper. The precision resistance was adjusted to a value slightly greater than *X* and the final adjustment obtained by adjusting the resistance of the bridge. This latter resistance would always be large, at least 500 ohms, so that the accuracy of the bridge as a whole was determined by the galvanometer and the precision resistance. One of the three leads to the thermometer was connected in the battery circuit, and the two other leads were placed one in each of the arms *X* and *R*. These latter two leads were at no time interchanged from the position they occupied at the time of calibration. A compensated aneroid barometer was used for measuring the barometric pressure. This barometer was compared at different times with the mercury barometer of the university observatory, and a calibration curve constructed.

[3]Scientific Paper 407.

Discussion of Sources of Error

The general sources of error that may be experienced in boiling-point determinations have been so well discussed by Smith and Menzies[4] and others that only those relating to this particular apparatus will be treated here.

Pressure and Temperature Control. — The vacuum regulator made it possible to maintain a constant mean difference between the barometric pressure and the pressure in the apparatus for as long a period as was desired. In some determinations the pressure in the apparatus actually oscillated as much as 0.3 mm. from the mean value, but as these oscillations were rapid and extremely regular, it may be safely assumed that their effect on the mean boiling point of the solution was nil. The temperature for all but the most concentrated and viscous solutions would be correspondingly equally constant. For the latter variations as much as 0.3 deg. C. were noted. In these cases the highest values obtained at a given pressure were taken as correct.

Temperature.—The platinum thermometer was calibrated against the temperature of melting ice, of steam above boiling water, and of the vapor above boiling naphthalene. From the resistance obtained at these three points the constants in the formula $R_t = R_0 (1 + \alpha t + \beta t^2)$ were determined. A calibration curve was then constructed using a scale such that 1 mm. corresponded to 0.1 deg. C. The values for temperature as read are calculated to be accurate to within less than 0.1 deg. C.

Pressure.—The pressures as measured by the mercury barometer and manometer were reduced to equivalent readings at 0 deg. C., 45 deg. latitude and sea level, and the values reported have all been so corrected. The steel rule used was compared with other standards and found to check to within less than 0.1 mm. at 25 deg. C. The height of the mercury column could be read as accurately as a mercury barometer. In taking these readings, the difference in height of the top of the meniscus in the two arms of the manometer was taken as the reading. It can be easily demonstrated that if the mercury column is oscillating regularly, the above reading is the true mean value. The mercury used had been purified by nitric acid, followed by a double distillation in vacuo.

Purity of Materials.—The materials used were sufficiently purified so that errors from this source could not cause an error of 0.1 deg. C. in the boiling point of any solution used. Dissolved gases, if any were present, would be completely swept out by the ebullistic method used, since about 20 minutes was allowed at each point for the system to come to equilibrium.

Superheat.—Superheating of the liquid was practically impossible, first, because the heat was conducted to the solution through metal, and second, because the solution that came in contact with the thermometer had been pumped by its own steam up the pumping tube onto the thermometer, thus giving time for the vapor and liquid to come into equilibrium with each other.

[4]"Studies in Vapor Pressure," *J. Am. Chem. Soc.*, vol. 32, p. 1412.

This also eliminated any possibility of the boiling point of the solution in which the thermometer was immersed being raised by the hydrostatic pressure of the liquid.

Accuracy of Complete Apparatus

To test the general accuracy of the complete apparatus determinations of the boiling point of water from 50 to 100 deg. C. were made, using the pumping tube exactly as in the case of a solution so that the thermometer was wet with the water pumped up. These results are presented in Table I. The fifth column of this table shows the corresponding values given by Peabody's Steam Tables,[5] which are based on accepted standard values of Holborn and Henning.[6] From these results, it would appear that the apparatus has an

TABLE I. COMPARISON OF BOILING POINT OF WATER AT DIFFERENT PRESSURES WITH VALUES OBTAINED BY HOLBORN AND HENNING

Corrected Barometer, Mm.	Corrected Manometer (Vacuum), Mm.	Corrected Absolute Pressure, Mm.	Temperature Observed, Deg. C.	Temperature From Steam Tables (H and H.) Deg. C.	Difference Deg. C.
736.8	613.2	123.6	56.00	56.00	0.00
726.6	485.8	240.8	70.72	70.71	—0.01
740.8	249.9	490.9	88.22	88.20	—0.02
741.0	168.1	572.9	92.29	92.27	—0.02
741.0	127.5	613.5	94.12	94.11	—0.01
741.0	78.4	662.6	96.20	96.20	0.00

absolute accuracy within this range of better than 0.1 deg. C. The accuracy of pressure measurement is believed to be well within 0.3 mm. It is evident that if the mercurial barometer against which the aneroid barometer was calibrated were in error by 0.3 mm., this would have made the measurement of the boiling point of water, at 123.6 mm. pressure, in error by 0.05 deg. C.

Critical Study of Data

The method of making a critical study of boiling point data described in a previous paper,[7] while satisfactory for most technical work, is not sufficiently exact to preserve the accuracy of data which have a probable absolute error of less than 0.1 deg. C. Data of this sort could be obtained by the use of a series of empirical formulas, such as those of Bertrand, but the labor involved in such a method would be enormous. In searching for a simple yet accurate method for studying the data, it was found that if at a pressure p_1 the solution boiled at a temperature t_1, and water boiled at a temperature θ_1 and that at a pressure p_2 the corresponding boiling points were t_2 and θ_2, then for p_n, t_n and θ_n, the following relationship would hold:

$$\frac{t_1 - t_2}{\theta_1 - \theta_2} = \frac{t_2 - t_3}{\theta_2 - \theta_3} = \frac{t_n - t_{n+1}}{\theta_n - \theta_{n+1}} = K,$$

where K is a constant. In other words, if a series of points were plotted on rectangular co-ordinate paper, showing for a given solution the temperatures at which the solution exerted certain vapor pressures plotted against the corresponding temperatures at which water would exert the same vapor pressure, then all the points so plotted would fall more nearly on a straight line than on any other smooth curve that could be drawn. This is essentially Dühring's rule. In 1878 Dühring[8] advanced the theory that if t_1 and t_2 are the boiling points of a substance at two pressures, p_1 and p_2, and if θ_1 and θ_2 are the boiling points of another substance at the same pressures, then $(t_1 - t_2) = q\ (\theta_1 - \theta_2)$ where q is a constant. Curiously enough, while this rule has been largely used for comparing the boiling points of different pure substances with the boiling points of water, it has apparently not been applied to aqueous solutions where the solute exerted practically no vapor pressure. The same statement holds true for the more general law of Ramsay and Young.[9]

The accuracy with which Dühring's rule can be applied to aqueous solutions of any strength, provided always that these solutions are not saturated and provided that the solute does not exert an appreciable vapor pressure, has not been generally appreciated. The application of this rule to several solutions is shown by the curves in Fig. 2. This graph shows as ordinates the boiling points of certain solutions at various pressures, and as abscissas the corresponding boiling points of water under the same pressures. The boiling point data for this graph were selected rather at random both from the literature and from determinations by the authors. Some of the solutions represented ionize highly, others

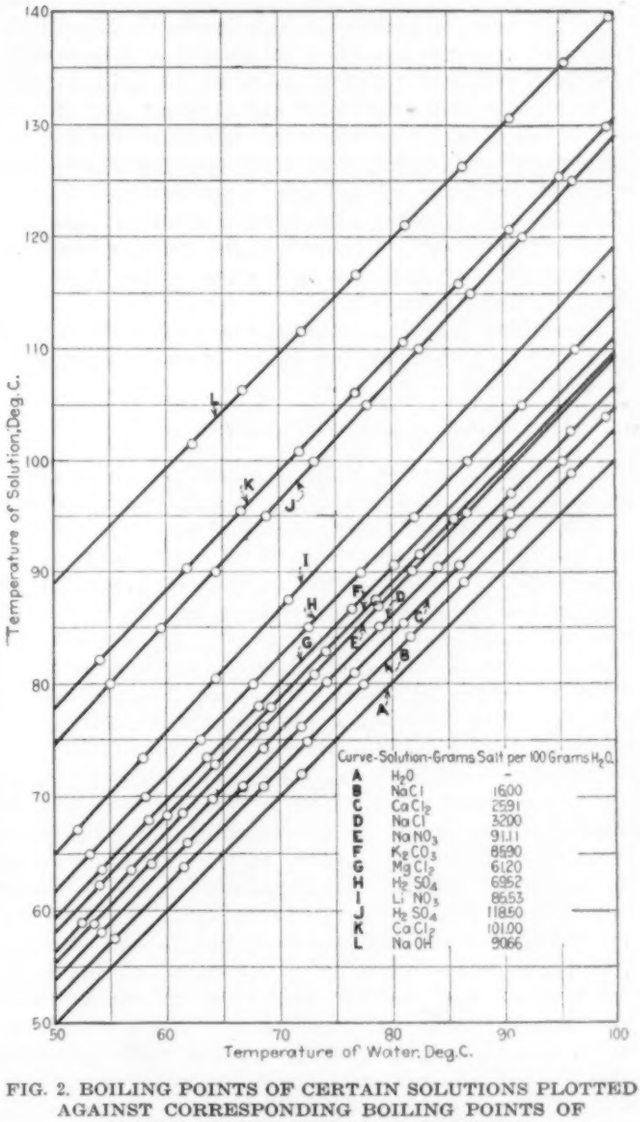

FIG. 2. BOILING POINTS OF CERTAIN SOLUTIONS PLOTTED AGAINST CORRESPONDING BOILING POINTS OF WATER UNDER THE SAME PRESSURE

[5] Eighth edition.
[6] *Ann. Phys.* (4), vol. 26, p. 833 (1908).
[7] W. L. Badger and E. M. Baker, *ibid.*
[8] Neue Grundgesetze sur nationelle Physik und Chemie (erste folge: Leipzig 1878).
[9] *Z. phys. Chem.*, vol. 1, p. 250.

to a less extent. Some of the solutes are not ordinarily considered to form a series of hydrated particles in solution, others are known to associate strongly. There is a great diversity of the chemical nature of the solutes considered. The actual data plotted are shown in each case by the circles. The curves as drawn are straight lines, and coincide with the data very closely. With few exceptions, the deviation is less than 0.1 deg. C., and in all cases the straight line more nearly represents the data than any other smooth curve that might be drawn. The variation of individual points from the straight line is presumably due to experimental error, and the general agreement of the data with Dühring's rule is most remarkable. That is to say, all these solutions obey the relationship $K = \frac{t_1 - t_2}{\theta_1 - \theta_2}$

Accordingly, if Dühring's rule holds, as this study indicates, in order to define completely and accurately the relationship of vapor pressure to the boiling point of an unsaturated solution of any strength (an infinite number of data), it is only necessary to record two relationships—viz., a curve or table showing the boiling point of solutions of different concentrations at one pressure, for example, atmospheric pressure; and the curve or equation which shows the relation between concentration of solutions and slope of the lines for these varying concentrations.

From these two sets of data, the boiling point of a solution of any composition at any pressure may be at once calculated.

Application of Dühring's Rule

It is evident that in order to obtain the above information, instead of carrying out an indefinite number of determinations of boiling points of solutions at different strengths and pressures, it is only necessary to determine the boiling points of each of a number of solutions of different concentrations at two pressures. One of these pressures will usually be atmospheric. Thus, the establishing of the relation expressed by Dühring's rule has greatly decreased the number of determinations necessary to obtain the information and has simplified the method of recording these data.

To define completely the whole system for saturated and unsaturated solutions, it is necessary to know, in addition to the above, the boiling point of the saturated solution at different pressures, or else the solubility of the solute at different temperatures. With either of these sets of data, a line can be drawn on the chart for the system which will show, at the various solution temperatures, the solubility of the solute. The area to one side of this line will then represent unsaturated solutions for which Dühring's rule will hold, the area to the other side will represent supersaturated solutions and these should not exist under the given conditions; and the line itself will define the boiling points of the saturated solution at different pressures.

We desire to emphasize again that the relationships expressed by Dühring's rule appear to hold, for unsaturated aqueous solutions where the solute does not exert an appreciable vapor pressure, more accurately than data which have been determined, without regard to (1) whether the concentration is high or low, (2) whether or not the solute ionizes, and (3) whether or not the molecules or ions of the solute take up water of hydration or association. It is not at all necessary that the solution be "ideal," to conform rigorously to the law.

It should be pointed out that the curves in Fig. 2 are not parallel (in general) either to each other or to the curve for water, nor is there a definite relation between the slope of the curves and the elevation of the boiling point at any given pressure.

It is planned to use the apparatus and the method as described in this paper in a number of investigations. Two such investigations have already been completed, and are to be published in subsequent papers.[10]

The authors desire to acknowledge the assistance received from the National Research Council, which made possible this work, and of the active interest taken by Prof. W. L. Badger of this department.

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Increased Production of Rosin and Turpentine

The production of rosin rose 29 per cent, or 350,000 round barrels, and that of turpentine 33 per cent, or 122,000 casks, during the season 1920-21 over that of the previous season, according to a recent statement of the United States Bureau of Chemistry.

The following table, compiled from reports from individual producers, shows the production of rosin by states for the last three years:

ROSIN PRODUCTION IN ROUND BARRELS

State	1918-19	1919-20	1920-21
Alabama	136,180	141,410	150,310
Florida	414,150	495,660	548,880
Georgia	215,550	262,050	425,530
Louisiana	165,300	130,430	214,580
Mississippi	109,120	119,610	175,810
N. Carolina	2,920	4,090	1,740
S. Carolina	2,340	3,430	8,250
Texas	68,600	64,090	52,290
Total	1,114,160	1,220,770	1,577,390

The production of turpentine by states is given below:

TURPENTINE PRODUCTION IN CASKS

State	1918-19	1919-20	1920-21
Alabama	41,580	43,800	47,220
Florida	125,680	144,180	170,870
Georgia	65,470	82,420	133,070
Louisiana	52,850	38,950	65,520
Mississippi	31,920	36,080	53,430
N. Carolina	880	1,340	530
S. Carolina	690	1,110	2,540
Texas	21,200	18,690	15,410
Total	340,270	366,570	488,590

On the Heat-Treatment of Aluminum Bronze

In the article "On the Heat-Treatment of Aluminum Bronze," by A. A. Blue, in the Dec. 7 issue of CHEMICAL & METALLURGICAL ENGINEERING, an error due to a misunderstanding occurred in Table V on page 1048. The table as corrected should read as follows:

TABLE V. PROPERTIES OF FORGED ALUMINUM BRONZE

Treatment	Tensile Strength, Lb. per Sq.In.	Elastic Limit, Lb. per Sq.In.	Elongation, per Cent	Contraction in Area, per Cent
Forged, untreated	79,750	34,360	32.5	34.8
Forged, untreated	81,245	34,240	31.0	30.8
Forged, reheated to 1,650 deg. F. and quenched in brine	92,190	44,820	Broke outside gage marks.	
Forged, reheated to 1,650 deg. F., quenched in brine, drawn to 1,000 deg. F. and cooled in lime	81,345	43,820	Broke outside gage marks.	
Forged, reheated to 1,650 deg. F., quenched in brine, drawn to 1,000 deg. F. and cooled in lime	86,490	47,760	12.0	14.9

[10] "Vapor Pressure of the System Calcium Chloride-Water," by E. M. Baker and V. H. Waite (to appear in an early issue of CHEM. & MET. ENG.). "Vapor Pressure of the System Sodium Hydroxide-Water and of Sodium Hydroxide-Sodium Chloride-Water," by E. M. Baker and A. R. Carr.

Fatigue of Metals Under Repeated Stress

Professors Moore and Kommers Believe That Carbon Steels Will Not Fail by "Fatigue" if Stressed Below a Definite Amount, Quickly Determined by Measuring the Heat Generated in the Specimen During the Test

AS HAS been noted in these columns, Professors Moore and Kommers, of the University of Illinois, have been conducting an investigation upon fatigue failure under the joint auspices of the University Engineering Experiment Station, the Engineering Foundation and the General Electric Co. Bulletin 124 of the Experiment Station describes in considerable detail the results so far obtained.

Table I gives the chemical analysis of the steels tested; each of these was heat-treated to bring it in that condition often found in machine parts. (See Table II.) Usual physical tests were performed with the results listed in Table III. Fatigue tests were made on a battery of machines designed along lines proposed by F. M. Farmer.[1] Specimen *A* is rotated in swivel end bearings, and carries the load *W* at two places, *C* and *D*. These arrangements are designed to throw a uniform bending moment in a cylindrical specimen, but in order to localize the failure, the test-piece was reduced to a neck 0.30 in. in diameter by a fillet of 9.85 in. radius. Final polishing was done with No. 00 emery cloth.

In making the rotating-beam test on the first specimen a stress was applied which would cause failure in a short time. In successive specimens the stress was reduced until a stress was reached which the specimen could withstand for 100,000,000 cycles without failure.

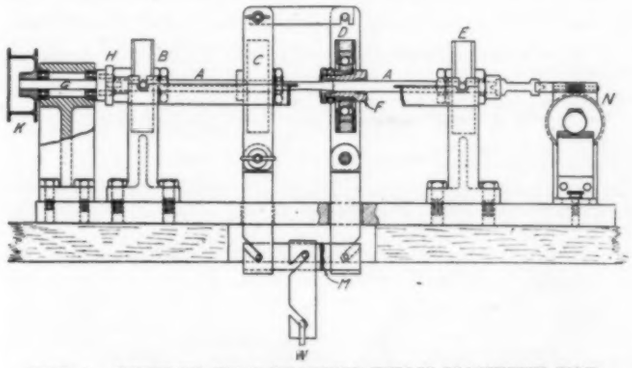

FIG. 1. SKETCH OF ROTATING BEAM MACHINE FOR MEASURING ENDURANCE OF METAL

Wherever possible these long-time tests without failure were run on from three to five specimens for each of the steels investigated. Altogether 963 reversed-stress tests were made.

Fig. 2 shows the results of fatigue tests on eutectoid steel No. 6. All the diagrams are plotted with logarithmic co-ordinates, stresses against number of cycles for rupture (*S-N* diagrams). The authors have interpreted all their plots to indicate that up to some value of *N* the results of the reversed-stress tests may be well represented by a sloping straight line, where there is a decided break. For higher values of *N* a horizontal straight line seems to represent the relation between *S* and *N*, up to a value of *N* of 100,000,000 cycles of stress, with no indication of a further break in the diagram. So far as they can see from their test results, the material would withstand an indefinite number of reversals of stress lower than the value corresponding to this break in the *S-N* diagram. To this safe stress the name "endurance limit" has been given,

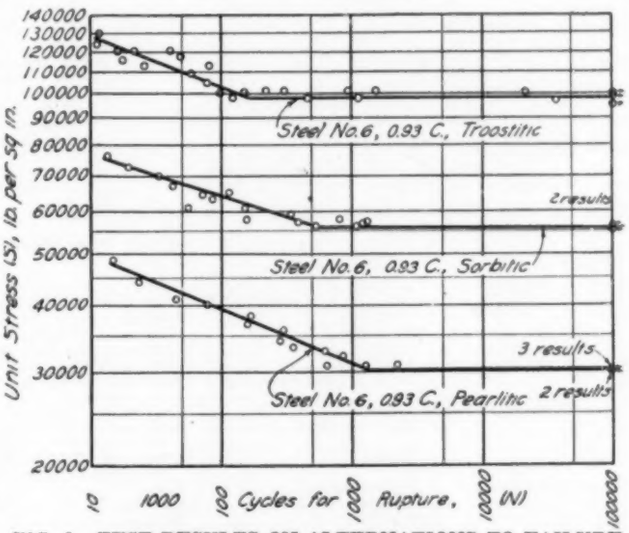

FIG. 2. TEST RESULTS ON ALTERNATIONS TO FAILURE OF EUTECTOID STEEL, VARIOUSLY HEAT-TREATED

and in all the steels tested it was developed at less than 10,000,000 reversals. In other words, a steel which will not break before 10,000,000 reversals can be expected to endure 100,000,000, and perhaps forever.

Searching for some short-time test for predicting fatigue resistance, this was found by measuring the rise of temperature[2] under a reversed stress applied for a few minutes or less.

The apparatus used in making the temperature test is shown in Fig. 3. The machine was designed to test the regular 13-in., rotating-beam specimen and to produce the same type of stress. Specimen *S* is held horizontally in V-notch grips *A*. The load is applied on a ball bearing *B*, at the end of the specimen, the bearing being heat-insulated from the specimen by a fiber collar $\frac{1}{16}$ in. thick. The machine is also heat-insulated from the base at points *E* and *F*, to prevent heat traveling from the bearings through the base to the specimen. The load on the specimen is measured by reading the deflection of the Ames dial *C*, a load-deflection curve

[1] American Society for Testing Materials, 1919.

[2] The temperature test was suggested and to some extent used by C. E. Stromeyer of Manchester, England, as long ago as 1913. He did not, however, have the opportunity of carrying out a sufficient number of long-time tests to establish thoroughly the temperature limit as identical with the endurance limit under repeated stress. It should be stated that the credit of developing the temperature test in connection with the present investigation should be given to J. W. Harsch, a member of the test party of the present investigation, and to Prof. W. J. Putnam of the department of theoretical and applied mechanics of the University of Illinois.

for the specimen having been previously obtained by recording a set of loads and corresponding deflection readings. The load can be varied by an adjusting screw, *D*, in the head of the machine. A thermocouple cannot be readily attached to a rotating specimen, and it will be noted that the machine is so designed that the specimen does not turn, but that the head of the machine rotates. The left-hand end of the specimen is thus moved in a circle concentric with its axis, the radius of the circle being the deflection coresponding to the desired stress.

Differential copper-constantan thermocouples were used to measure the rise of temperature. One couple was attached at the section of greatest stress *K*, and was held directly against the specimen by means of tape. The other couple was at *L*, a section of zero stress, and was separated from the specimen by a single layer of thin paper. The couples were connected in series, and the free wires lead to a D'Arsonval galvanometer. When the couples were at the same temperature no deflection of the galvanometer was shown, but when the temperature became different a corresponding deflection occurred.

The temperature test consists in running the machine at a speed of 1,000 r.p.m. for 30 seconds, using a known stress and recording the maximum deflection of the galvanometer. Then with a series of such readings, corresponding to a series of stresses, a curve like those of Fig. 4 is plotted to show the increase in temperature with increase of stress. The point at which the curve shows a sharp break corresponds to the endurance limit. In the cases of sorbitic structures in plain carbon steels and in that of alloy steels it was found necessary to increase the time of the run, at

TABLE I. CHEMICAL ANALYSIS OF STEELS TESTED

Steel No.	Furnished by	Material Furnished in	Content, Per Cent — Carbon	Chromium	Nickel	Silicon	Manganese	Phosphorus	Sulphur
1	Illinois Steel Co.	2 x 1 flats	1.20	....	....	0.19	0.25	0.021	0.021
3	John A. Roebling's Sons Co.	Billets, 4 in. square	0.52	....	....	0.24	0.56	0.037	0.029
4	John A. Roebling's Sons Co.	Billets, 4 in. square	0.37	....	....	0.16	0.58	0.032	0.035
5	Halcomb Steel Co.	2 x 1 flats	0.24	0.87	3.33	0.15	0.37	0.019	0.025
6	Carnegie Steel Co. through Standard Steel Co.	2 x ¾ flats	0.93	....	....	0.03	0.38	0.017	0.045
7	Midvale Steel & Ord. Co. through General Electric Co.	1 in. squares	0.41	0.18	3.41	0.25	0.75	0.020	0.020
9	American Rolling Mill Co.	1 in. rounds	0.02	....	....	0.02	0.03	0.005	0.042
10	Inland Steel Co.	1⅛ in. squares	0.49	....	....	0.12	0.46	0.017	0.029
50	J. T. Ryerson & Son, (cold-drawn screw stock)	⅞ in. rounds	0.20	....	....	0.03	0.67	0.025	0.090
51	University of Illinois stock (hot-rolled reinforcing rod)	¾ in. rounds	0.18	....	....	0.06	0.37	0.013	0.039

TABLE II. HEAT-TREATMENTS OF STEELS TESTED

Steel	Structure	Heat-Treatment
No. 1—1.20 Carbon	Normalized	Heat to 1,460° F.; hold 15 min.; cool in furnace (this anneals the steel so that it can be machined); then heat to 1,580° F.; hold 15 min. Cool in furnace with door open.
	Sorbitic	First anneal as above; then heat to 1,470° F.; quench in oil; reheat to 860° F.; hold 30 min.; cool in air.
No. 3—0.52 Carbon	Normalized	Heat to 1,550° F.; hold 15 min.; cool in air.
	Sorbitic	First normalize as above; then heat to 1,450° F.; hold 15 min.; quench in water; reheat to 1,200° F.; cool in air.
No. 4—0.37 Carbon	Normalized	Heat to 1,495° F.; hold 15 min.; cool in furnace with door open.
	Sorbitic, Treatments *A* & *B*	This steel was not first normalized. Heat to 1,550° F.; hold 15 min.; quench in water; reheat to 1,050° F.; cool in air.
No. 5 Chromium-Nickel	Treatment *A*	Steel received annealed. Heat to 1,525° F.; quench in oil; reheat to 700° F.; quench in oil.
	Treatment *B*	Steel received annealed. Heat to 1,525° F.; hold for ½ hour, quench in oil. Reheat to 1,450° F.; quench in oil; reheat to 1,200° F.; hold for 1 hour, cool in furnace.
	Treatment *C*	Steel received annealed. Heat to 1,525° F.; hold for ½ hour, quench in oil; reheat to 1,450° F.; quench in oil; reheat to 1,200° F.; hold for 1 hour; quench in water.
No. 6—0.93 Carbon	Normalized	Heat to 1,600° F.; hold 15 min.; cool in air.
	Pearlitic	First normalize as above; then heat to 1,450° F.; hold 15 min., cool in furnace.
	Sorbitic	First normalize as above; then heat to 1,450° F.; hold 15 min., quench in oil; reheat to 1,200° F.; hold 30 min. cool in air.
	Troostitic	First normalize as above; then heat to 1,450° F.; hold 15 min., quench in oil; reheat to 850° F.; hold 30 min.; cool in air.
No. 7—Nickel	Treatment *B*	Normalize by heating to 1,525° F. and cooling in furnace; then heat to 1,525° F.; quench in oil; reheat to 1,210° F.; hold 2 hours; cool in furnace.
No. 9—0.02 Carbon	Ferrite	Teated as received.
No. 10—0.49 Carbon	Normalized	Heat to 1,700° F.; hold 20 min.; cool in air.
	Sorbitic	First normalize as above; then heat to 1,427° F.; quench in water; reheat to 1,200° F.; cool in furnace.
No. 50—Cold-drawn	As received	
	Annealed	Heated to 1,300° F.; hold for 15 min.; cool in furnace.
	Annealed	Heated to 1,550° F.; hold for 15 min.; cool in furnace.
No. 51—Hot-rolled	As received	
	Cold-stretched	Reduced to diameter of 0.44 in.; then heated to 500° F.; cool in furnace.
	Cold stretched	Reduced to diameter of 0.48 in.; then heated to 500° F.; cool in furnace.
	Cold bent	Bent to an angle of 45° at the middle, straightened cold.

TABLE III. RESULTS OF PHYSICAL TESTS

No.	Steel	Tension — Proportional Elastic Limit	Ultimate	Per Cent of Elongation	Per Cent of Reduction of Area	Hardness — Brinell	Scleroscope	Impact Bending Energy of Rupture, Ft.Lb.	Impact Tension — Energy of Rupture, Ft.Lb.	Per Cent of Elongation	Per Cent of Reduction of Area	Compression — Proportional Elastic Limit	Ultimate	Torsion — Proportional Elastic Limit	Modulus of Elasticity
9	As received	16,100	42,400	48.3	76.2	69	18	19.3	84.9	27.0	72.7	19,200	31,200	12,500	11,770,000
51	As received	38,200	61,500	41.0	66.7	...	..	....	.....	....	....	.....	.....	.....	.....
51	Reduced to 0.48 in.	60,000	67,600	22.3	63.3	...	..	....	.....	....	....	.....	.....	.....	.....
51	Reduced to 0.44 in.	69,600	73,400	14.2	59.5	...	..	....	.....	....	....	.....	.....	.....	.....
51	Bent cold and straightened	.....	.....	....	....	...	..	....	.....	....	....	.....	.....	.....	.....
50	As received	55,200	86,800	13.8	49.3	...	..	....	.....	....	....	.....	.....	.....	.....
50	Annealed at 1,300 deg. F.	26,700	56,600	41.3	65.5	...	..	....	.....	....	....	.....	.....	.....	.....
50	Annealed at 1,550 deg. F.	28,000	57,700	40.8	63.2	...	..	....	.....	....	....	.....	.....	.....	.....
4	Normalized	34,500	71,900	29.4	53.5	132	18	15.8	168.4	32.4	52.7	36,300	59,200	20,300	11,790,000
4	Sorbitic—Treatment *A*	80,600	102,600	23.3	65.1	209	26	53.2	163.2	24.0	62.8	75,800	102,800	51,600	11,960,000
4	Sorbitic—Treatment *B*	61,500	94,200	25.0	63.0	...	..	....	.....	....	....	.....	.....	.....	.....
10	Sorbitic	67,700	96,900	23.5	57.8	197	23	22.5	152.3	24.0	55.1	55,900	76,500	36,800	12,150,000
3	Normalized	45,400	98,000	24.4	41.7	193	24	13.2	188.5	24.2	45.6	47,800	78,700	30,000	11,720,000
3	Sorbitic	80,300	111,400	21.9	56.6	227	30	21.4	172.0	22.2	55.1	84,400	97,800	52,200	12,115,000
6	Pearlitic	28,000	84,100	24.8	37.2	162	23	2.2	141.3	21.2	34.5	23,500	69,200	15,600	11,880,000
6	Sorbitic	60,300	115,000	23.0	39.6	227	31	3.3	193.2	21.6	43.9	64,800	97,100	42,000	12,130,000
6	Troostitic	97,200	188,300	9.9	29.3	380	51	4.4	186.8	15.0	41.3	106,500	.....	75,200	11,960,000
1	Normalized	58,600	116,900	7.9	11.6	224	31	1.9	88.8	8.8	14.6	55,300	96,500	36,500	11,700,000
1	Sorbitic	120,400	179,900	9.0	15.2	369	45	2.0	109.1	6.3	11.0	102,700	149,200	80,600	11,940,000
7	Treatment *B*	82,400	111,800	23.6	60.2	242	28	41.0	179.9	22.8	57.4	86,400	95,100	55,500	11,890,000
5	Treatment *A*	115,500	138,700	18.2	61.8	291	36	45.4	173.8	17.0	61.7	122,600	133,000	72,400	11,510,000
5	Treatment *B*	101,700	113,300	24.2	68.7	247	28	53.8	175.3	22.2	63.2	97,800	100,300	62,500	11,980,000
5	Treatment *C*	86,200	114,200	23.2	69.3	246	29	56.0	187.6	23.4	67.0	91,500	99,900	62,300	12,020,000

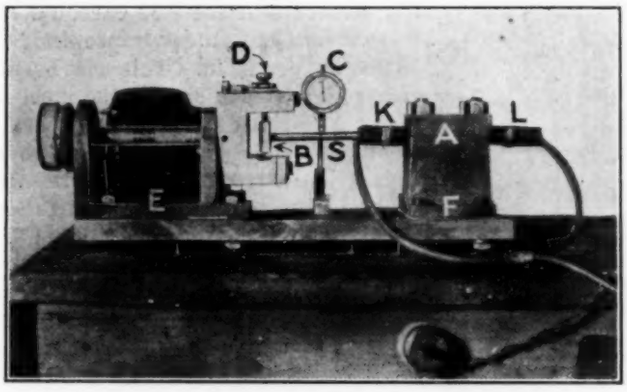

FIG. 3. BENDING MACHINE FOR MEASURING HEAT DEVELOPED DURING ALTERNATE STRESSING

each stress, from 30 seconds to 2 minutes, since these materials are slower in heating under stress.

A reference to Table IV and Fig. 5 shows a very good degree of coincidence between the values of endurance limit determined by the temperature test and those values determined by long-time rotating-beam tests.

Various physical properties of the steels used in this investigation are plotted in Figs. 5 and 6. It is apparent that the endurance limit (by rotating beam and logarithmic plot) corresponds most closely to the rise in temperature determinations. Fairly good parallelism exists between the curve for endurance limit and curves for Brinell hardness and ultimate tensile strength. Other properties vary widely. In none of the steels did the endurance limit under completely reversed stress fall below 36 per cent of the ultimate tensile strength; in only one metal did the endurance limit fall below 40 per cent of the ultimate tensile strength, while for several metals the endurance limit was more than 50 per cent of the ultimate tensile strength. In this connection it should be noted that the steels tested were to a high degree free from inclusions and other internal defects, that the specimens had no abrupt changes of outline, and that they had a good surface finish.

Effect of Shape of Specimens on Endurance Limit.—Previous investigators have shown that the shape of the specimen may exert a very great influence on the endurance strength of the material. Square shoulders and sharp notches are known to reduce the endurance limit as much as 50 per cent.

A study of this matter was first made in this investigation on a 0.49 carbon, sorbitic steel. It was found that specimens which had their diameter reduced by a fillet 1-in. radius were almost as strong as those in which a radius of 9.85 in. was used. A ½-in. radius reduced the strength about 8 per cent, square shoulders reduced the strength about 51 per cent, and a V-notch reduced the strength about 60 per cent. Square shoulders and a ¼-in. radius showed about the same effect on a very soft 0.02 carbon as they did with the harder steel first mentioned.

Effect of Surface Finish on the Endurance Limit.—It has been known that the condition of the surface of a specimen may exert a marked influence on the fatigue strength of steel. A study of this matter was first made on a 0.49 carbon, sorbitic steel. One series of specimens was finished very carefully in order to remove all scratches and was finally given a very high rouge polish. It was found that these specimens were only slightly stronger than those finished with the standard finish. Specimens with a ground finish were slightly weaker than those with the rouge finish, smooth-turned still weaker, and rough-turned weaker even than the smooth-turned. The rough-turned specimens were about 18 per cent lower in endurance limit than those finished with the rouge polish. Similar results on the smooth-turned and rough-turned specimens were found with a very soft 0.02 carbon steel.

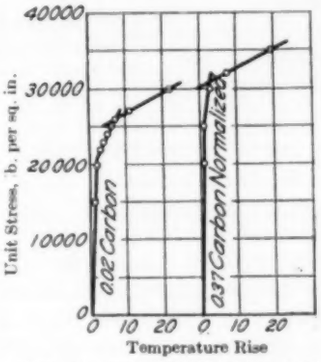

FIG. 4. TEST RESULTS ON MACHINE ILLUSTRATED IN FIG. 3

Effect of Overstress on Endurance Limit.—In order to determine whether stressing a specimen above its normal endurance limit would have a serious effect on the endurance limit under subsequent stresses, a number of different combinations of overstress and cycles of rupture were tried on a 0.49 carbon, sorbitic steel. For instance, one series of specimens was given 5,000 cycles of stress at a unit stress 10 per cent higher than its normal endurance limit. These specimens were then tested in the usual way to determine whether the over-

TABLE IV. ENDURANCE LIMITS

No.	Steel	Endurance Limits: Farmer Rotating Beam	Endurance Limits: Upton-Lewis Reversed Bending	Endurance Limits: Olsen-Foster Reversed Torsion	Francke Bending *Fk* Point in Francke Test	Repeated Impact Number of Double Blows	Rise of Temperature Test
9	0.02 Carbon, as received	26,000	23,000	12,500	.....	260	26,000
51	Hot-rolled—as received	28,000	.....	.....	.....	242	27,000
51	Hot-rolled—reduced to 0.48 in.	35,000	.....	.....	.....	280	38,500
51	Hot-rolled—reduced to 0.44 in.	41,000	.....	.....	.....	361	40,500
51	Hot-rolled—bent cold and straightened	30,000	.....	.....	.....	.....	.....
50	Cold-drawn—as received	41,000	.....	.....	.....	316	41,500
50	Cold-drawn—annealed at 1,300 deg. F.	29,000	.....	.....	.....	202	27,500
50	Cold-drawn—annealed at 1,550 deg. F.	25,000	.....	.....	.....	223	.....
4	0.37 Carbon normalized	33,000	30,003	16,000	33,000	183	31,000
4	0.37 Carbon sorbitic—treatment *A*	57,000	.....	32,500	.....	550	.....
4	0.37 Carbon sorbitic—treatment *B*	45,000	.....	.....	44,000	503	49,000
10	0.49 Carbon sorbitic	48,000	39,000	26,000	.....	319	48,000
3	0.52 Carbon normalized	42,000	32,000	.....	39,500	275	41,500
3	0.52 Carbon sorbitic	55,000	44,000	.....	66,000	486	53,000
6	0.93 Carbon pearlitic	30,500	28,500	16,300	34,000	66	28,500
6	0.93 Carbon sorbitic	56,000	44,000	.....	.....	128	53,000
6	0.93 Carbon troostitic	98,000	.....	52,000	.....	227	90,000
1	1.20 Carbon normalized	50,000	45,000	.....	.....	39	43,000
1	1.20 Carbon sorbitic	92,000	.....	.....	.....	172	88,000
7	3½ Nickel—treatment *B*	63,000	.....	.....	.....	524	62,500
5	Chromium-nickel—treatment *A*	68,000	52,000	37,000	62,000	1,073	66,000
5	Chromium-nickel—treatment *B*	65,000	.....	31,500	.....	714	65,000
5	Chromium-nickel—treatment *C*	67,000	.....	.....	.....	722	70,000

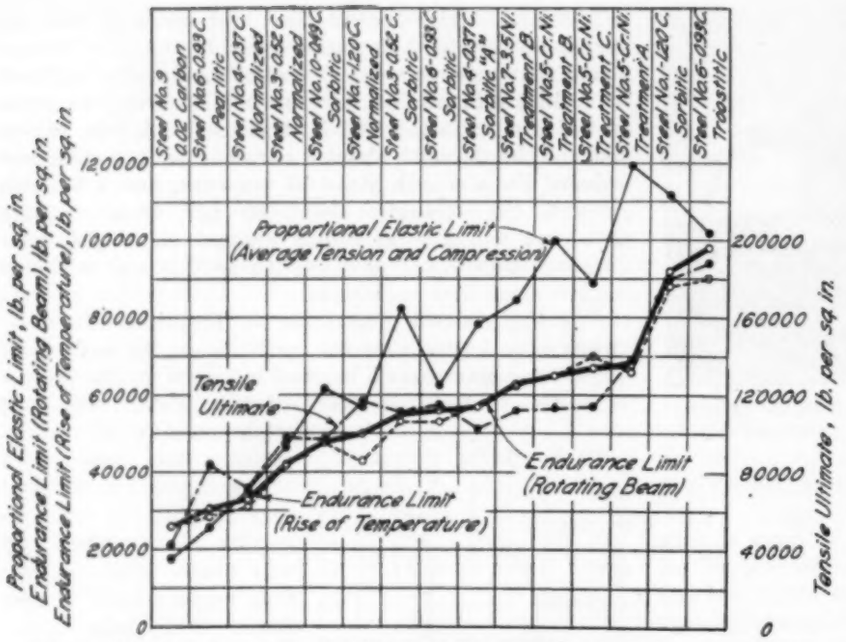
Steel No. 9 0.02 Carbon
Steel No. 6-0.93 C. Pearlitic
Steel No. 4-0.37 C. Normalized
Steel No. 3-0.52 C. Normalized
Steel No. 10-0.49 C. Sorbitic
Steel No. 1-1.20 C. Normalized
Steel No. 3-0.52 C. Sorbitic
Steel No. 6-0.93 C. Sorbitic
Steel No. 4-0.37 C. Sorbitic "A"
Steel No. 7-3.5 Ni. Treatment B
Steel No. 5-Cr-Ni. Treatment B
Steel No. 5-Cr-Ni. Treatment C.
Steel No. 5-Cr-Ni. Treatment A.
Steel No. 1-1.20 C. Sorbitic
Steel No. 6-0.93 C. Troostitic
Proportional Elastic Limit, lb. per sq. in. Endurance Limit (Rotating Beam), lb. per sq. in. Endurance Limit (Rise of Temperature), lb. per sq. in.
Tensile Ultimate, lb. per sq. in.
Proportional Elastic Limit (Average Tension and Compression)
Tensile Ultimate
Endurance Limit (Rotating Beam)
Endurance Limit (Rise of Temperature)
120000
100000
80000
60000
40000
20000
0
200000
160000
120000
80000
40000
0

FIG. 5. COMPARATIVE PHYSICAL PROPERTIES OF STEELS UNDER TEST

stressing had changed the endurance limit. It was found that 10 per cent and 20 per cent of overstress applied 5,000 times, 29 per cent of overstress applied 1,000 times and 38 per cent of overstress applied 100 times did not reduce the endurance limit appreciably. On the other hand, 35 per cent of overstress applied 1,000 times reduced the endurance limit about 4 per cent and 29 per cent of overstress applied 5,000 times reduced the endurance limit 11 per cent. It seems that a material may be able to withstand a considerable amount of overstress if the overstress is applied only a comparatively small number of times. Tests on a hard, high-carbon steel gave similar results to those above mentioned, the percentage of reduction being somewhat higher than for the soft steel.

Various Factors Influencing the Endurance Limit.—It is a well-known fact that the effect of subjecting steel to a tensile stress beyond the yield point is to raise the static elastic strength to a marked degree, as is illustrated by the strength of cold-drawn and cold-rolled steel. It was found in the case of a 0.18 carbon steel that the effect of such cold work was less marked on the endurance limit than on the static elastic strength, though some increase of the endurance limit was observed after cold working. Annealing of commercial cold-drawn screw stock was found to reduce its endurance limit.

Fig. 2 illustrates the effect of heat-treatment on the endurance limit. In the very soft condition of the pearlitic structure of the 0.93 carbon steel the material has an endurance limit of 30,500 lb. per sq.in. This can be increased by 84 per cent if the steel is given a sorbitic structure by heat-treatment, and by 221 per cent when it is given a troostitic structure. In general, a heat-treatment which raises the static elastic strength and the ultimate tensile strength raises the endurance limit also, but the increase in static strength is not a reliable indicator of the amount of increase in endurance limit.

In those cases in which the same steel was tested in a hard and a soft condition the results show that giving the material a sorbitic structure by heat-treatment may greatly increase the endurance limit without much sacrifice of ductility.

The results thus far obtained on eight different steels in reversed torsion indicate that the ratio of the endurance limit in torsion to the endurance limit in bending is about 0.52.

With one very soft steel it was found that the computed stress at the endurance limit in bending was actually about 33 per cent higher than the proportional elastic limit in tension. This material was almost pure ferrite and the result indicates that homogeneity of structure is a valuable factor in giving a high resistance against fatigue. Results indicate that thorough annealing also produces a high ratio of endurance limit to proportional elastic limit. It is quite possible to have a high ratio of endurance limit to proportional limit, when both are low.

Only one nickel and one chromium-nickel steel were investigated. The results indicate that the alloy steels have somewhat higher endurance limits for the same ductility, as compared with plain carbon steels.

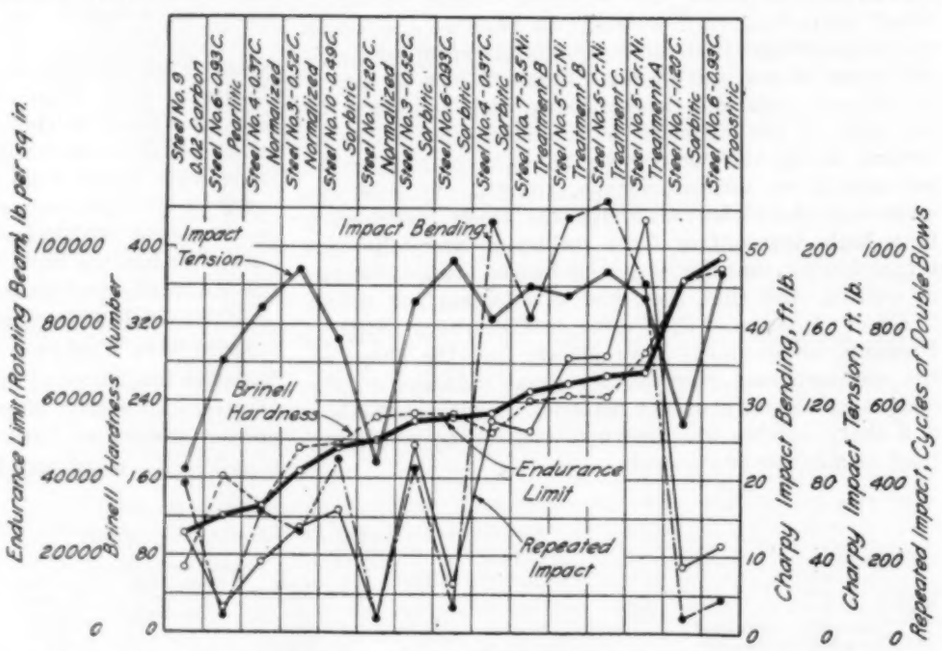

FIG. 6. COMPARATIVE PHYSICAL PROPERTIES OF STEELS UNDER TEST

Distillation Studies of Nitric Acid and Sulphuric-Nitric Acid Mixtures—II

Equilibria in the System Water:Nitric Acid:Sulphuric Acid During Distillation at Various Pressures —Graphic Study of the Phenomena of Distillation—Application of the Experimental Data to the Preconcentration and Superconcentration of Nitric Acid

BY PAUL PASCAL
With the experimental assistance of Mr. Garnier

Study of the Ternaries: Water, Nitric Acid Sulphuric Acid

THE addition of sulphuric acid to a nitric acid modifies the volatility of the latter greatly. The phenomenon may be pictured by assuming that the sulphuric acid forms, with the water of the mixture, a non-volatile hydrate in an enriched nitric acid solution. The variation in the boiling point of the mixture with the first addition of sulphuric acid is determined principally by this "enrichment" in nitric acid, only later does the increase in the concentration of the sulphuric acid intervene, and the boiling temperature then rises in all cases.

It may thus be foreseen that the first addition of sulphuric acid will raise the boiling point of weak acids and lower that of strong acids.

But the most regular and most manifest effect of the addition of sulphuric acid is a rapid enrichment in nitric acid of the vapors emitted during boiling, and in a progressive effacement and displacement of the maximum toward acids of low nitric content.

In the zone of acids poor in water the boiling point varies very little as long as the sulphuric acid content remains below 60 to 70 per cent, but the nitric acid vapor emitted is then colored strongly red by the products of dissociation of the acid, and the true boiling point is distinctly lowered by this disturbing factor.

There are shown in Table IV the results of our experiments at various pressures, acids having about the same sulphuric acid content being grouped together. A final series comprehends mixtures which were almost anhydrous and which boiled with a partial dissociation of the vapor, at temperatures certainly too low; we have, however, included them because of the interest they present in practical operation.

The results of all these experiments may be reviewed by plotting in triangular co-ordinates the contours of the surface of boiling points, of which the altitude of the different points is a measure of the corresponding boiling point. Figs. 5, 6, 7 and 8 hold for the pressures 317, 458, 570 and 760 mm. respectively; the apexes of the reference triangles, *N*, *H* and *S*, represent 100 per cent nitric acid, water and 100 per cent sulphuric acid.

The contour lines have been plotted every 10 deg., and there has been added in dotted line the contour through the highest point of the maximum boiling point line, which, depending on the pressure, corresponds to 96, 104.5, 112.1 and 121.5 deg. C. respectively. For aqueous sulphuric acid the boiling point data of Bryce Cudleigh Burt [*J. Chem. Soc.*, vol. 85, p. 1339 (1904)] have been used.

The momentary lowering of the maximum boiling point on the addition of sulphuric acid to a nitric acid of 65 to 68 per cent is noticeable, as well as the disappearance of this maximum in acid of this strength to which about twice its weight of sulphuric acid has been added and the rapid variation of the boiling point for mixtures containing three times as much sulphuric as nitric acid, for a water content of 15 to 20 per cent

But these acids of rapidly varying boiling point are just those employed in the manufacture of nitrocotton and it is known how strictly interdependent are the water content and the degree of nitration. It is thus possible to see in our results a justification of Saposchnikoff's contention that the degree of nitration of the cotton is directly influenced by the nitric acid vapor pressure of the bath. In the region which interests us, a small variation in water content displaces the boiling point considerably and in the same way affects the partial pressure of the nitric acid; it is thus comprehensible that it may cause the nitrogen content of the nitrocotton to vary rapidly.

COMPOSITION OF THE VAPORS EMITTED

The concentration in nitric acid, of the vapors emitted by mixed acids boiling under normal pressure is represented by the ternary diagram, Fig. 9, in which have been given, every 10 per cent, the boundaries of the mixtures giving vapors of the same composition. Lowering the pressure displaces the curves scarcely at all, in the direction of a higher acidity.

The distribution of the vapor composition curves shows besides, at least for mixtures not too rich in water nor too poor in nitric acid, that the composition of the vapor depends solely upon the water content of the boiling mixture. When there is less than 30 per cent of water in the liquid, the vapor contains less than 10 per cent water, with relatively little decomposition products, while for weaker acids the strength of the vapors rapidly decreases.

GRAPHIC STUDY OF THE PHENOMENA OF DISTILLATION

Let us designate by *n* the locus of the points representing the mixtures which on distillation yield a vapor of concentration *n* (Fig. 10). During this distillation the representative point *P* of the liquid, located at each instant upon a different curve *n*, is displaced continuously along the segment *nP* which joins *P* with the point *n* on the line *NH*, representing the vapor which passes over. The line *nP* is thus, at each instant, tangent to the trajectory at the point *P*, so that the line of the route passed over by the representative point of

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For Part I see CHEM. & MET. ENG., vol. 25, No. 24, Dec. 14, 1921.

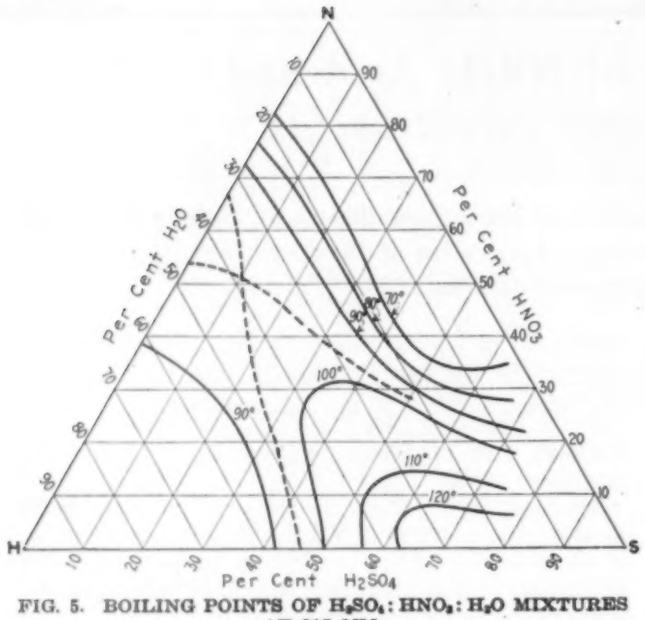

FIG. 5. BOILING POINTS OF H_2SO_4: HNO_3: H_2O MIXTURES AT 317 MM.

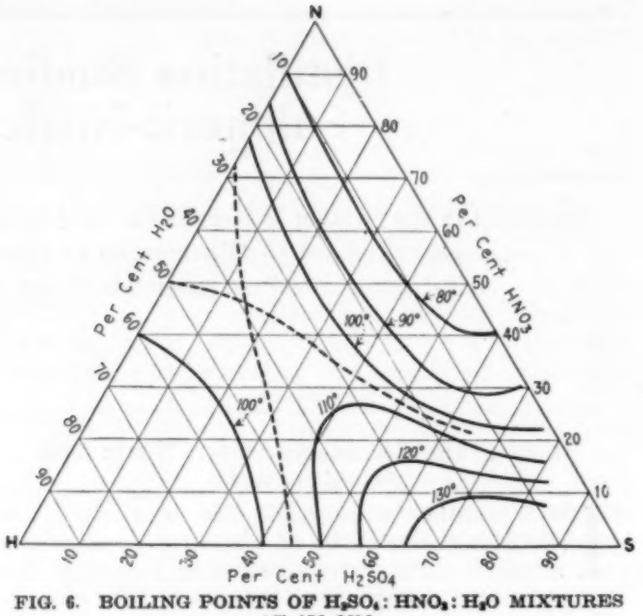

FIG. 6. BOILING POINTS OF H_2SO_4: HNO_3: H_2O MIXTURES AT 458 MM.

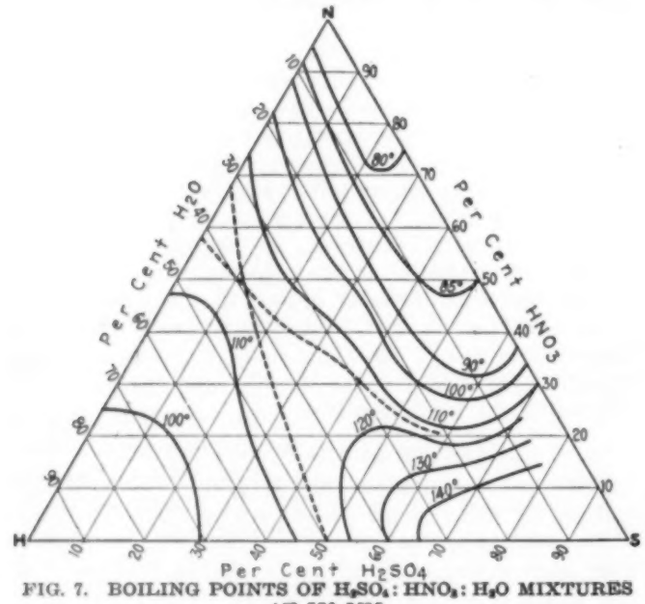

FIG. 7. BOILING POINTS OF H_2SO_4: HNO_3: H_2O MIXTURES AT 570 MM.

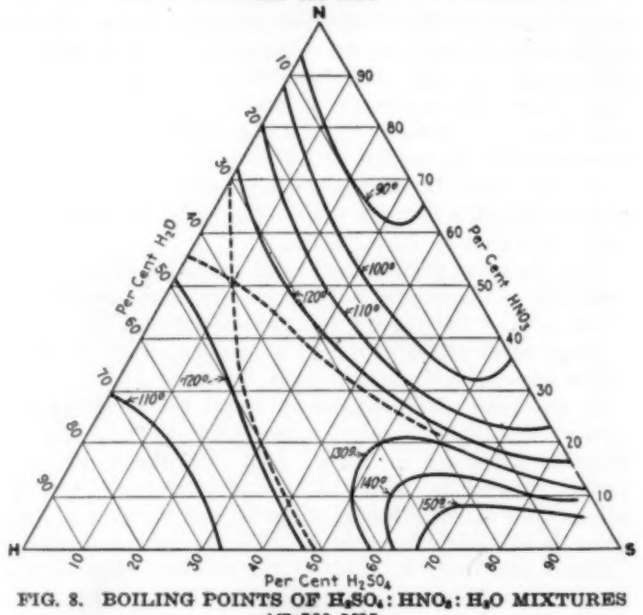

FIG. 8. BOILING POINTS OF H_2SO_4: HNO_3: H_2O MIXTURES AT 760 MM.

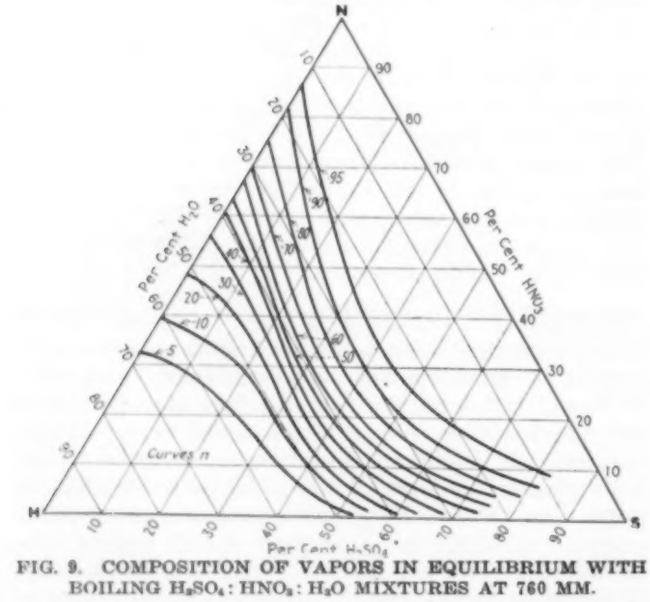

FIG. 9. COMPOSITION OF VAPORS IN EQUILIBRIUM WITH BOILING H_2SO_4: HNO_3: H_2O MIXTURES AT 760 MM.

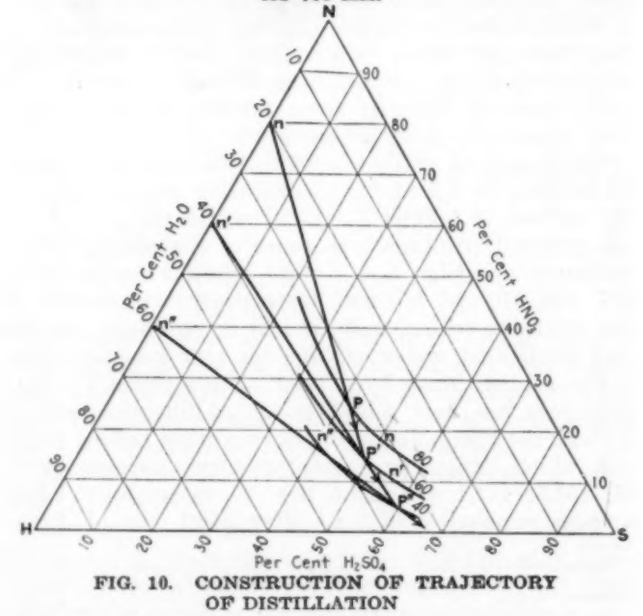

FIG. 10. CONSTRUCTION OF TRAJECTORY OF DISTILLATION

Note: The above curves were copied directly from the figures shown in the original article, which do not agree any too w[ell] the numerical data. For very accurate work it will hence be necessary to redraw the curves.—F. C. Z.

the boiling liquid determines the series of rectilinear elements PP', $P'P''$, $P''P'''$ . . . , which join the necessive points P, P', P'' . . . to the points n, n', n'' . . . corresponding to the curves n traversed at each instant by the trajectory of the point P. We propose to call this the trajectory of distillation. It is at once apparent that through one point on the plan passes one trajectory of distillation, but only one; the system of these curves is thus formed by a series of lines which nest into one another without crossing.

Three curves worthy of note then present themselves in the plan of this figure:

1. Let us draw from a point n on the line NH a horizontal which cuts the corresponding curve n at M_o. The locus C_o of the points M_o (Fig. 11) represents the locus of the points where the trajectory of distillation possesses a horizontal tangent; or, in other words, the moment when the boiling liquid passes through a maximum concentration of nitric acid.

2. Let us draw the locus C_1, the intersections of the

TABLE IV. DISTILLATION EQUILIBRIA FOR THE SYSTEM WATER : NITRIC ACID : SULPHURIC ACID

Pressure, Mm. Hg	Boiling Pt., Deg. C.	Liquid: per Cent, HNO_3	Liquid: per Cent, H_2SO_4	Vapor, per Cent, HNO_3
Acids of About 10 per Cent H_2SO_4				
300	87	23.75	10.20	5.92
440	95	25.20	10.31	4.25
570	102	25.30	9.90	4.05
760	110	25.30	9.98	4.10
300	92.0	37.11	9.91	23.0
440	103.0	40.10	10.20	20.1
550	107.5	39.53	10.01	16.25
760	117.0	40.02	9.91	15.52
760	121.0	46.70	10.70	36.0
760	121.2	48.00	10.0	38.5
300	97.0	49.00	10.0	38.5
440	104.5	49.23	10.30	45.0
570	112.5	50.00	10.10	50.5
760	121.5	50.25	10.18	50.17
300	96.0	52.11	10.00	57.02
400	103.0	50.88	10.20	50.19
440	104.0	50.88	10.20	50.2
760	121.0	50.69	10.10	56.0
300	95.0	57.10	10.0	79.0
400	102.5	56.23	9.98	76.0
440	103.5	56.23	9.98	76.23
550	110.0	57.0	10.1	75.28
760	120.5	58.0	10.8	75.0
300	89.0	64.0	12.8	95.15
440	102.0	60.80	9.0	92.50
550	97.5	69.10	10.0	92.15
760	117.5	62.0	8.20	95.60
300	78.5	72.27	10.38	98.98
440	89.0	71.27	10.08	98.18
550	92.5	73.23	10.40	97.20
760	102.0	72.50	11.00	96.51
Acids of About 20 per Cent H_2SO_4				
300	85.0	20.01	20.18	3.2
440	97.5	20.22	20.71	3.2
550	103.0	20.31	21.22	3.3
760	113.0	20.10	21.37	3.1
300	93.5	30.15	21.20	9.8
440	103.0	31.33	21.31	10.0
550	110.0	30.05	20.21	9.7
760	119.5	30.01	19.98	10.0
300	96.0	34.5	20.18	30.0
440	106.0	35.20	20.27	29.7
550	112.0	35.10	21.02	28.9
760	122.0	35.02	20.07	28.5
300	97.0	41.22	21.00	68.0
440	106.0	39.29	20.90	67.5
550	112.0	40.07	20.37	66.0
760	122.0	41.01	20.01	64.2
300	94.0	50.11	20.65	83.0
440	104.5	50.53	20.50	82.0
550	110.0	50.17	19.98	82.8
760	120.0	50.50	20.18	82.0
300	71.5	64.29	20.17	97.2
440	84.5	64.10	21.02	96.5
550	91.5	64.17	19.97	96.5
760	102.5	64.13	20.29	96.2
Acids of About 30 per Cent H_2SO_4				
300	89.0	11.23	32.15	4.1
440	100.0	11.05	32.16	3.0
550	107.5	10.95	31.18	2.4
760	116.0	11.28	32.00	2.0
300	94.5	21.02	32.15	14.0
440	104.5	20.15	31.17	13.0
550	111.5	21.02	31.23	12.4
760	121.5	19.05	32.10	10.0
300	98.0	32.18	32.17	67.6
440	108.0	31.19	32.25	65.0
550	114.5	30.98	32.18	62.0
760	124.0	32.0	31.05	63.0
300	97.6	39.35	31.23	92.7
440	102.5	39.75	31.19	92.5
550	110.0	39.66	32.30	92.0
760	120.0	40.01	32.09	91.50
300	71.0	56.23	31.75	99.80
440	82.5	55.14	32.20	99.55
550	83.0	54.98	31.23	99.50
760	99.0	55.25	30.10	99.14
Acids of About 40 per Cent H_2SO_4				
300	98.0	10.01	40.05	23.21
440	106.0	12.25	42.38	24.15
550	114.0	10.05	41.25	22.18
760	124.0	10.01	41.15	21.42
300	102.0	15.76	42.92	34.18
440	111.0	15.95	42.86	35.06
550	117.5	16.40	42.08	35.20
760	127.0	15.23	40.07	35.49
300	105.0	20.18	41.15	73.25
440	112.0	20.05	41.03	73.17
550	118.0	19.75	42.53	71.0
760	128.0	18.08	46.31	70.80
300	100.0	29.85	39.85	92.0
440	105.5	29.75	40.25	91.82
550	110.0	30.18	40.10	91.18
760	119.5	31.50	41.05	90.50
300	71.5	34.18	41.57	99.27
440	82	35.06	40.57	98.36
550	102.5	35.20	40.39	96.02
760	110	34.49	41.05	98.54

Pressure, Mm. Hg	Boiling Pt., Deg. C.	Liquid: per Cent, HNO_3	Liquid: per Cent, H_2SO_4	Vapor, per Cent, HNO_3
Acids of About 50 per Cent H_2SO_4				
300	104.0	11.21	47.46	33.0
440	114.5	10.13	47.60	32.5
550	120.5	10.29	48.22	32.5
760	130.0	10.05	49.81	42.0
300	106.5	14.97	51.17	61.5
440	116.0	15.17	49.98	61.5
550	122.5	15.21	49.15	60.0
760	133.5	15.07	49.93	60.0
300	106.0	19.28	51.07	91.7
440	116.0	19.36	52.18	91.6
550	122.0	19.52	51.99	91.0
760	133.0	19.49	52.06	90.0
300	80.0	30.18	51.20	98.00
440	89.0	29.19	51.03	98.02
550	100.0	29.89	51.15	97.08
760	110.0	30.28	50.05	97.50
300	66.5	41.05	51.22	99.70
440	80.0	40.35	50.15	99.80
550	86.5	40.10	49.95	99.60
760	97.5	41.50	50.10	99.15
Acids of About 60 per Cent H_2SO_4				
300	116.0	6.10	61.01	51.17
440	127.5	5.21	59.95	51.10
550	135.0	4.99	59.98	49.20
760	145.0	5.13	60.21	48.00
300	116.5	10.01	59.95	68.51
440	127.5	10.28	59.98	68.10
550	135.0	10.17	60.17	67.75
760	145.0	10.01	60.18	67.00
440	103.0	21.05	59.99	99.93
550	110.0	19.95	60.21	98.99
760	120.0	19.99	60.67	98.77
300	71.00	31.93	61.00	99.94
440	82.50	32.19	59.93	99.93
550	89.00	33.0	59.61	99.0
760	99.00	32.0	59.0	98.91
300	105.0	19.07	59.99	98.27
440	116.0	18.16	60.15	98.0
550	124.0	18.21	61.01	98.10
760	134.0	18.01	60.23	97.5
Acids of About 65 per Cent H_2SO_4				
300	121 (?)	9.95	65.17	90.20
440	132.0	10.17	67.0	89.75
550	137.5	11.0	66.11	89.0
760	147.0	10.07	65.15	89.55
300	95.0	21.02	64.33	99.60
440	106.0	20.53	64.49	99.60
550	112.5	19.98	65.57	99.60
760	118.0	20.10	64.90	99.15

Almost Anhydrous Mixed Acids

Pressure, Mm. Hg	Boiling Point, Deg. C.	Liquid: HNO_3	Liquid: H_2SO_4	Liquid: NO_2	Vapor: HNO_3	Vapor: NO_2
300	66	59.27	38.62	0.75	93.45	4.0
440	79	57.29	40.10	0.75	92.63	4.54
550	87	57.12	40.0	0.95	92.86	4.10
760	91	57.28	40.12	0.74	92.55	4.13
300	54	73.95	23.0	1.19	93.84	3.93
440	73	73.45	22.5	1.19	93.70	4.00
760	87.5	73.48	23.5	1.17	92.89	4.15
300	75	30.62	66.63	0.63	96.31	1.27
440	86	30.40	66.90	0.64	94.08	2.15
550	95	31.14	66.93	0.63	92.78	3.17
760	104	28.73	68.05	0.63	90.49	4.15
300	67	39.22	44.60	0.50	97.47	1.11
440	79.5	39.58	44.0	0.60	97.40	1.10
550	87	39.09	44.2	0.80	97.26	1.20
760	97	39.32	44.5	0.50	97.23	1.21
300	73	35.18	47.28	0.60	97.62	1.00
440	85	34.80	47.16	0.80	97.55	1.01
550	90	35.12	47.20	0.60	97.39	1.07
760	100	34.58	48.0	0.60	97.50	1.02
300	66	38.73	54.0	0.2	97.86	1.00
440	78	38.09	54.2	0.3	97.57	1.17
550	88	38.19	54.0	0.3	97.56	1.20
760	98	38.47	58.9	0.9	97.43	1.22
300	66	47.45	45.6	0.4	97.78	1.00
440	78	48.19	45.2	0.3	97.33	1.22
550	84	48.43	45.1	0.2	97.32	1.15
760	94	47.98	45.0	0.6	96.80	1.31
760	88.5	67.18	27.0	0.6	95.91	1.79
760	84	87.73	9.0	0.2	95.05	2.23
760	92	57.33	35.4	0.8	96.47	1.49

straight lines Sn with the corresponding curves n. All the trajectories of distillation cut C_1 in such a manner that at the point of coincidence the tangent passes through the point S representing sulphuric acid.

But if a mixed acid is regarded as a mixture of 100 per cent sulphuric acid and a dilute nitric acid which it is desired to concentrate, curve C_1 divides the plan into two noteworthy regions. All the points of curve C_1 represent those mixtures which at the instant the distillation begins give off vapors of the same composition as the nitric acid it was desired to concentrate. The left-hand region thus contains all the weak mixtures, which at the beginning of the distillation give off vapors less rich than the initial nitric acid; the

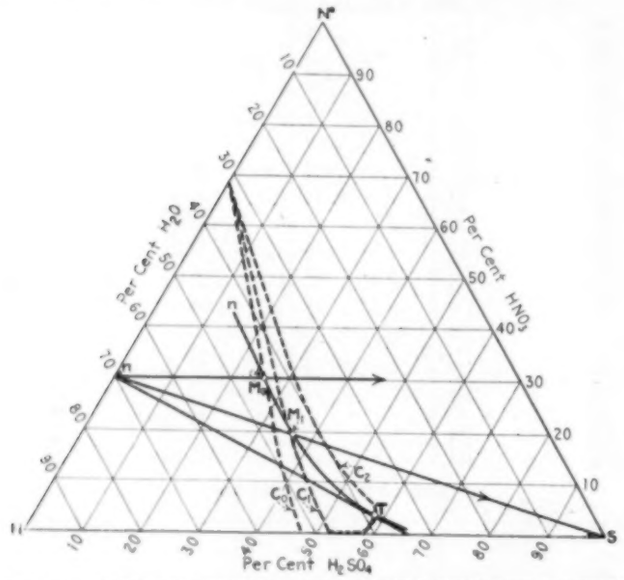

FIG. 11. CURVES DIVIDING PLAN INTO REGIONS HAVING SPECIAL PROPERTIES

right-hand region, on the contrary, corresponds to mixtures giving off stronger vapors. Actually curve C_1 is very near curve C_0.

3. Finally, let us draw from each point n on the side NH a tangent nT to the corresponding curve n. The locus of the points of contact T will be a third noteworthy curve C_2. From what has preceded, all the points of this curve belong to the trajectories of distillation which are tangent to the corresponding curve n at this point; and at this moment the liquid will emit a vapor of the concentration n. But the form and the position of the curves n is such that they are not cut by the trajectories that are exteriorly tangent to them. On both sides of the point T the trajectory thus passes through points corresponding to emitted vapors of a lower composition than n.

The curve C_2 is thus the locus of representative points through which the liquid passes at the moment when it is emitting a vapor of maximum concentration. But the extremity of the tangent which sweeps the line NH turns back at the moment when its point of contact falls upon the curve C_2, just when the concentration of nitric acid in the vapor passes through a maximum. The curve C_2 is thus equally the locus of the points of inflection of the trajectories of distillation; their concave side, turned toward the bottom in the region of weak liquids, turns up toward the top of the triangle in the region of more concentrated liquids.

The curve C_2, moreover, divides the plan into two remarkable regions:

1. The region adjacent to the apex H, containing points representing mixtures of which the vapors pass through a maximum of acidity during distillation.

2. The opposite region, containing points representing mixtures of which the vapors emitted during distillation have a constantly decreasing acidity.

Fig. 12 gives several examples of trajectories of distillation. It is easy to verify that if the system of trajectories is superimposed on the system of isotherms (Figs. 5, 6, 7 and 8) the point representing the liquid being distilled is displaced continually toward an increasing boiling point.

The relative location of the three curves C_0, C_1 and C_2 shows also that the moment when the vapors emitted possess a maximum acidity does not in general correspond with the moment when the liquid passes through a maximum nitric acid acidity. This phenomenon does not occur except when the original mixtures are represented by points on C_2 or to the left of C_2.

It is to be noted, finally, as follows from their definition, that the three curves C_0, C_1 and C_2 run together at a point on the line HN corresponding to that of the maximum boiling point.

Application of the Preceding Study

The curves of Fig. 3 permit the operation of the apparatus used for preconcentrating weak nitric acid from the arc process to be accounted for.

Imagine that at the base of one of these apparatus a relatively weak acid is boiled, represented by the point L in Fig. 13. It will give off a vapor more

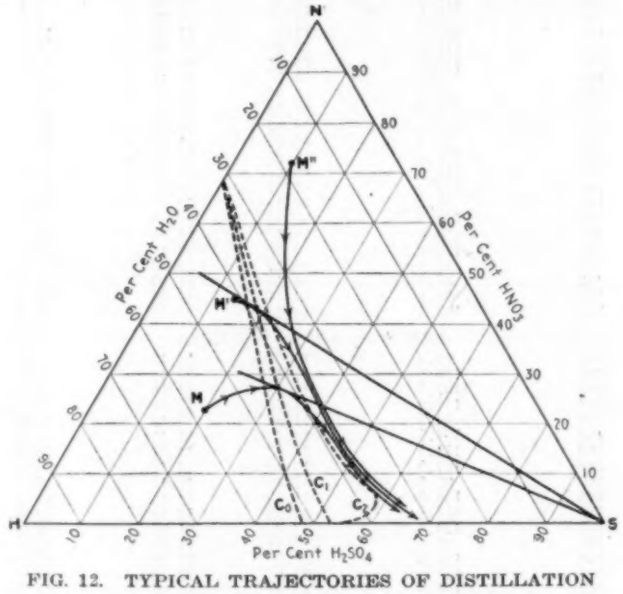

FIG. 12. TYPICAL TRAJECTORIES OF DISTILLATION

dilute, represented by V, and will consequently leave behind a residual liquid L_1 which is richer and boils at a higher temperature L_2.

If the vapor emitted enters a plate column, it condenses on one of the plates to a liquid layer which boils at a lower temperature L' and which as a consequence emits a vapor still less acid. Thus, by the operation of the column the vapors circulating in the upper part of the column will become poorer and poorer in acid, the residual liquids more and more concentrated.

A time will come, however, where the composition of the boiling liquid approaches that of the maximum, the vapors condensed upon the different plates will be nearer and nearer the composition of the boiling

liquids; the column will become insufficient and 68 per cent HNO_3 will not be attained in the residual acid, at least without raising to an excessive point the strength of the weak liquors.

The very flattened shape of the dewpoint curve fortunately makes it possible to employ the usual columns for an already very extended preconcentration, and at the plants of Rossi, where the process has been carried out with success, acids of 60 per cent strength are easily obtained when starting with the very weak acids

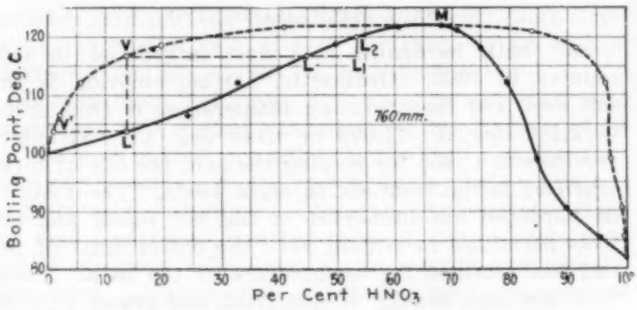

FIG. 13. DISTILLATION CURVE FOR NITRIC ACID

from the Pauling arc process. This fortunate circumstance gives a great interest to preconcentration, still too little extended, which offers great economy in fuel.

It is indeed of interest to evaporate an important part of the water contained in the weak acid, of which the heat of dilution is low; there is thus avoided the difficulty of making the same separation later from the dilute sulphuric acid which results from the final concentration of the nitric acid and which must return to the cycle after its strength is raised, at the expense of much coal used at much higher temperatures.

A weak nitric acid, strengthened, if need be, by preconcentration, may be transformed by distillation into concentrated and even anhydrous acid, if it is mixed beforehand with a sufficient amount of sulphuric acid.

As is known, the operation may be carried out in retorts, or better, in columns, made of towers filled with acid-proof material, down which runs the mixed acid, while superheated steam is injected at the base. We will examine in turn the theory of these two processes.

Let us treat this question in the most general way. To obtain a relatively concentrated nitric acid by distillation of any mixture of sulphuric and nitric acid whatever, the operation may be carried out in two different ways, depending upon the composition of the original mixture. (See Fig. 14.)

Let us suppose, first, that the point representing the original mixture is to the left of the curve C_2; there is collected, then, by the complete condensation of the vapor a nitric acid whose acidity (the original value given by the tangent m_0M_0 to the trajectory of distillation) constantly increases up to the end of the operation (total distillate). When, for example, the point representing the residual acid reaches the position M_1, the condensed acid has the total composition m_1, and the weight collected is the fraction $M_1M_0 \div M_1m_1$ of the original mixture.

At M_2, situated on the curve C_2, the distilling vapors have the maximum concentration, but the same is not yet true of the total condensed acid, represented by m_2, for beyond this point the concentration of the vapors drops slowly enough to compensate for the initial dilution of the distillate. The concentration m_3 of the acid collected is not reached until the boiling liquid reaches the point of contact M_3 on the trajectory of distillation. This is the time to stop the distillation, for from this moment the tailings will cause the concentration of the total distillate condensed to drop toward the limiting value M_4, given by the intersection of NH and the straight line SM_0.

When, on the contrary, the representative point M'_0 is to the right of the curve C_2 (and this is the case for the mixtures generally denitrated), the acid distilled, with an initial concentration m'_0 ($m'_0M'_0$ tangent to the trajectory of distillation at M'_0) decreases constantly in strength to the minimum value m'_2, determined by the straight line SM'_0.

For mixtures weak in nitric acid, as acids to be denitrated always are, the point m'_2 is always located very low; it is thus necessary to cut off before the end of the distillation. This is done the moment when the increase in the amount of acid collected appears to be neutralized by its progressive dilution. A good yield of concentrated acid is never obtained.

We will state to begin with that the system of curves n almost coincide at different pressures, with a mere tendency for the vapors to become richer when the pressure is lowered (and consequently when the temperature drops). It consequently results that, throughout their heating, the mixed acids emit a vapor which varies little in composition and becomes only a little less rich in nitric acid as boiling point is approached.

The mixtures of weak nitric acid and concentrated sulphuric acid, or better yet waste acids, which are

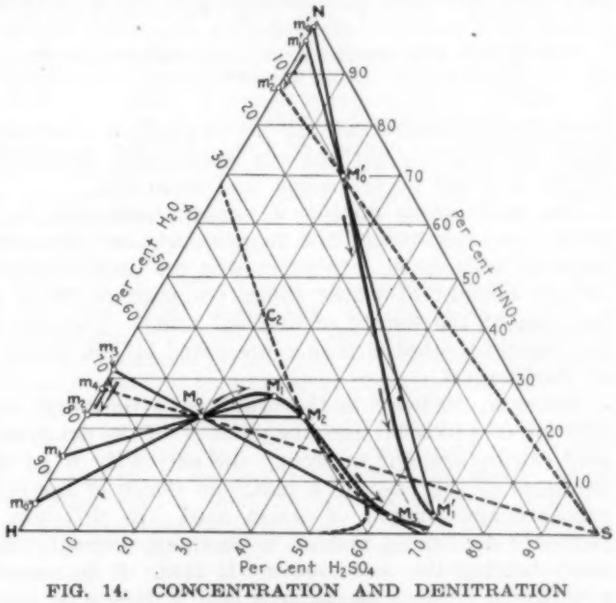

FIG. 14. CONCENTRATION AND DENITRATION IN RETORT

handled in towers, contain generally, roughly: HNO_3, 15 per cent; H_2O, 15 per cent; H_2SO_4, 70 per cent.

They are represented by the point A (Fig. 15). In its rapid descent over the packing or the plates of the tower, the liquid is but imperfectly in equilibrium with the surrounding vapors. Also, the concentrated vapors emitted by the distilling liquid are diluted by the weaker vapors from the lower part of the tower; instead of an acid C_3, of more than 95 per cent, passing over, somewhat stronger even than the acid determined by the original tangent At to the trajectory at A, the apparatus gives in regular operation an acid whose strength corresponds only to the point C.

When the distillation is carried out in a kind of recti-

fying apparatus of silicon iron,[8] heated externally, the "denitrated" acid depends upon the operating temperature T of the bottom of the column. If TBB' is the isotherm corresponding to the surface of boiling points, the acid run out at the base of the column is generally incompletely denitrated, and its representative point B, situated at the intersection of AC and the isotherm, permits a determination of the fraction $B'B_1 \div BB_1$ of nitric acid lost.

When, on the other hand, the distillation is made in towers into the base of which live steam is injected, a

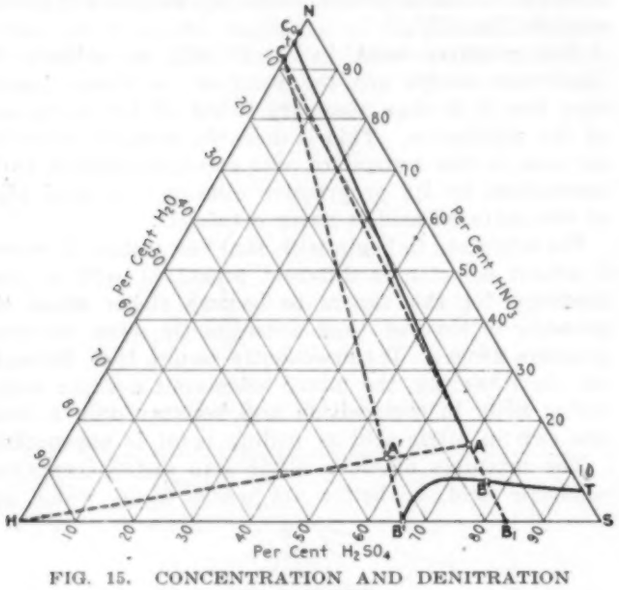

FIG. 15. CONCENTRATION AND DENITRATION IN A TOWER

much better denitration may be obtained, for the same heat consumption, without any appreciable diminution in the strength of the nitric acid separated.

The acid which distills is again represented by a point near the end of the tangent At, but this time there is introduced into the tower the acid A plus a certain amount of water vapor (in practice 10 to 12 per cent of the weight of original acid). The sum of the liquids treated is then represented by the point A' on the line AH.

But now, contrary to the progress of the "dry" distillation of a moment ago, the point B' of the denitrated acid can be brought to occupy the extremity B' of the isotherm of the base by a judicious choice of the temperature and amount of steam used. In this way a perfectly denitrated residue is obtained, without, however, diluting the recovered nitric acid. It is common practice to produce 92 per cent acid in this way, starting with the acid mentioned above and leaving as residue a sulphuric acid of 62 per cent H_2SO_4.

This easy carrying over of nitric acid by steam, from sulphuric acid mixtures, is moreover a property well known to analysts who determine the nitric acid of mixed acids by the difference in acidity of the liquids, first of the original, then of the residue after this has been diluted with water and evaporated several times.

I will add in conclusion that all of the preceding study may be applied in all cases of distillation of ternary mixtures of which only two constituents are volatile under the conditions of the experiment.

Scientific Faculty of Lille.

[8]See Pascal, Synthèse et catalyses industrielles, chez Janny, à Lille.

Various Methods for Hardening High-Speed Steel

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IN THIS paper I will state briefly the advantages and disadvantages of different hardening methods for high-speed steel, proposed in the 20 years which have intervened since Taylor and White made their recommendations.

Salt Bath Hardening

Salt bath hardening was first introduced in this country in 1902. Ordinarily, barium chloride is the salt used and the operating temperature is from 2,000 to 2,100 deg. F. (1,093 to 1,149 deg. C.) Graphite crucibles are used for holding the salt, the life of these crucibles being from six to eight heats. The tools to be hardened are immersed in the hot liquid and the tools permitted to remain until the entire mass of the tool has attained the temperature of the bath. These tools are then usually oil-quenched, and drawn to from 400 to 600 deg. F. (204 to 316 deg. C.) in oil, depending upon the kind of tool.

No scaling takes place by this method, thus producing a cleaner tool than in muffle furnace hardening, but the method has the following disadvantages: (1) The quenching temperature is too low. (2) Soft scale is sometimes produced. (3) Blistering and pitting sometimes occurs. (4) Pots are very short lived.

It is a well-known fact that to obtain the highest degree of red-hardness, partial austenization must take place. This means quenching from a temperature of 2,200 deg. F. (1,204 deg. C.) and upward; indeed, the higher the quenching temperature above 2,200 deg. F. (1,204 deg. C.) up to about 2,350 deg. F. (1,288 deg. C.) the greater the effect called "secondary hardening"—the added hardness gained by tempering quenched steel. We have heated small test-pieces of high-speed steel 1½ hours in a barium chloride bath at 2,100 deg. F. (1,149 deg. C.), but the microstructure was the same as when left in the bath just long enough for the heat to soak through.

Blistering and pitting of tools heated in a barium chloride bath are said to be due to particles of the graphite crucible which have broken loose coming in contact with the tools and sticking to them. Sometimes these blisters or beads drop off, leaving pits. The longer service the bath has seen the more loss is suffered through this blistering and pitting.

A graphite pot lasts only from six to eight heats, making this method of hardening quite a costly one. A new salt is now being introduced for the hardening of high-speed steel, which can be maintained at a temperature of 2,200 deg. F. (1,204 deg. C.), thus being superior to the barium chloride bath. The container used is a graphite crucible with a cast-steel liner. In this way the steel pot is protected from the flame, and there is no danger of blistering or pitting from particles floating through the bath.

Pack Hardening

Pack hardening consists of packing the high-speed tools with charcoal in a suitable container. The container is then luted carefully with clay, and the whole placed in a furnace, the temperature brought up to around 2,200 deg. F. (1,204 deg. C.) and held there a

considerable length of time. Tools are then removed, oil-quenched or air-cooled.

This method gives a tool free of scale, but has the following decided disadvantages: (1) Quenching temperature is too low, and (2) tools are carburized. We obtained the temperature of some test-pieces with an optical pyrometer just before they were removed from the pack, and found the temperature to be about 2,050 deg. F. (1,121 deg. C.), although the furnace temperature was 2,200 deg. F. (1,204 deg. C.), and they had remained 1½ hours at heat. Scleroscope tests and micrographs verified this temperature. Furthermore test-pieces showed a gain of 0.40 per cent carbon on the surface after being given the pack treatment.

I have been informed by two different men who attempted this method that at times the cutting edges of the tools melted, due either to the higher carbon content of the surface of the tools or to the tools coming in contact with each other. One other experimenter tried to use a cast-iron box for packing, but as cast iron melts at about 2,200 deg. F. the results can well be imagined. Carborundum powder has been suggested as a substitute for charcoal for a packing material, as the former would not carburize the steel. In the writer's opinion, however, high-speed tools treated in this way would be inferior to tools heated in the semi-muffle furnace, because the steel would have to remain at a high temperature for a long time when pack hardened, thus producing a coarse-grained structure.

Lead Bath Hardening

A lead bath was tried quite extensively about 10 years ago for heating high-speed tools, but the method did not prove a success. At 2,200 deg. F. the vapor pressure of lead is about 20 mm. of mercury, so that severe volatization will inevitably ensue. It is also quite a problem to find pots to hold the same. Difficulty is also experienced in controlling the time of immersion, as lead is a very rapid heating medium. A metallurgist for one of the large tool steel mills in England told me recently that a large amount of high-speed steel was hardened in his country by the lead bath treatment. He stated that they were able to obtain a very pure grade of lead and could operate at a temperature of 2,300 deg. F. (1,260 deg. C.).[1] His method for hardening a 1-in. high-speed hand reamer would be to preheat to 1,500 deg. F. (816 deg. C.) in a muffle furnace, then transfer the tool to the lead bath whose temperature was 2,350 deg. F. (1,288 deg. C.), hold there 15 seconds and cool in an air blast.

Semi-Muffle Furnace Hardening

Most of the high-speed steel hardened in this country is heated in semi-muffle furnaces, oil or gas fired. It is always advisable to have these furnaces equipped with pyrometers, using noble metal couples. The optical pyrometer is also satisfactory for controlling these high-temperature furnaces.

Work to be hardened should be preheated to 1,500 to 1,600 deg. F. (816 to 871 deg. C.), and when thoroughly heated through at this temperature, transferred to the high-temperature furnace, whose temperature is higher than the desired hardening heat. The tool is left in this furnace until the cutting edges have attained the proper temperature—about 2,300 deg. F. (1,260 deg. C.)—and the material then quenched. Soaking at the high temperature is to be avoided, as it coarsens the grain and is likely to "burn" the steel. In such practice the time factor is evidently just as important as the temperature. Quenched tools are then drawn to the desired temperature. One great advantage of this method of hardening is the high temperature attainable, thus producing the greatest degree of red-hardness and almost complete solution of the carbides. The disadvantage is that the tool scales to a degree, which can be reduced to a minimum by a thorough preheating and the proper mixture of fuel and air in firing the high-temperature furnace. Large high-speed tools have been very successfully hardened by using two preheating furnaces; the first is maintained at a temperature of about 1,100 deg. F. (593 deg. C.) and is used as a stock furnace. The temperature of the second preheater is 1,700 to 1,800 deg. F. (927 to 982 deg. C.). The material will not scale in the first preheating furnace; while the steel will oxidize in the second preheater, it requires less time to bring it to heat, thus reducing scaling to the least possible amount.

[1] At this temperature the vapor pressure of lead is nearly 50 mm. of mercury (see J. Johnston, *J. Ind. Eng. Chem.*, vol. 9, p. 873 (1917).

Synopsis of Recent Chemical & Metallurgical Literature

Liberation of Ammonia From Coal and Coke.—At the recent annual meeting of the Institution of Gas Engineers of Great Britain, A. C. Monkhouse and Prof. J. W. Cobb reported the results of experiments undertaken by them to determine the influence of atmosphere upon the products of carbonization and its bearing upon the production of ammonia from coal. A complete report of the investigation appeared in the Oct. 21, 1921, issue of the *Iron and Coal Trades Review*. The work was especially directed toward the comparative behavior of nitrogen, hydrogen and steam in influencing the further yield of ammonia when carbonization at a low temperature (500 deg. C.) had been already effected. On carbonizing coal the authors found that the percentage of the total nitrogen of the coal obtained as ammonia is 10 to 25 per cent. The greater portion—40 to 80 per cent—is left in the coke; the remainder is found as free nitrogen and cyanogen in the gas, and a little in the tar. The liberation of ammonia in carbonization processes has been shown to be affected by various factors, such as: (1) *The Rate of Distillation.*—The slower the rate of distillation the more nitrogen is usually obtained as ammonia. (2) *The Nature of the Coal.*—Generally speaking, the older the formation of the coal geologically the smaller is the proportion of the total nitrogen obtained as ammonia. (3) *The Temperature of Distillation.*—The higher the temperature of distillation the less nitrogen is left in the coke. Temperatures above 500 deg. C. are necessary for a good yield of ammonia. In complete gasification with air and an excess of steam, as in the Mond process, the yield of ammonia is much higher than in carbonization—60 to 70 per cent. Our method was to take a particular coal and to coke it at three definite temperatures—500, 800 and 1,100 deg. C.—so preparing soft, medium and hard cokes. The action of hydrogen on these three cokes was then determined at three different temperatures—600, 800 and 1,000 deg. C. In order to differentiate between any specific action of hydrogen on the nitrogen compounds and the influence of an inactive gas, similar experiments were made using nitrogen instead of hydrogen. Comparison with steam followed.

A New Etching Agent for Chromium and Tungsten Steels.—Karl Daeves, in *Stahl und Eisen*, Sept. 8, 1921, p. 1,262, emphasizes the advantages of potassium ferricyanide as an etching reagent for Cr and W steels, first proposed by K. Honda and T. Murakami. According to the Japanese authors, there are three carbides in Cr steels—namely, α-carbide $(Fe_3C)_{12}Cr_4C$, β-carbide $(Fe_3C)_6Cr_4C$ and γ-carbide

$Fe_3C.Cr_4C$. A mixture of 10 g. potassium ferricyanide and 10 g. KOH in 100 c.c. water acts as follows: α-carbide is attacked even in the cold, giving a brown to blue coloration; β-carbide is attacked only when hot, and γ-carbide is not attacked. High-speed steel with over 12 per cent tungsten contains the compound Fe_3W, which is easily attacked by the cold reagent, giving a brown to blue coloration.

Dr. Daeves has also made further studies on the advantages of a potassium ferricyanide etching reagent and recommends the following solution: 20 g. potassium ferricyanide, 10 g. sodium hydroxide, 100 g. water. The following table summarizes the results found on various analyses:

Sample	Analysis, per Cent C	Cr	W	Action of the Etching Reagent: Cold Reagent	Boiling Reagent
1	2.18	9.8	....	Coloration of the eutectic.....	Same as for cold reagent, but deeper (black) coloration.
2	1.94	5.2	....	Ditto.....	Ditto.
3	1.23	0.54	....	None.....	Grain boundaries slightly brown.
4	0.8	5.00	....	Coloration of the eutectic.....	Same as for cold reagent but deeper.
5	0.54	5.25	....	Traces of the eutectic colored..	Ditto.
6	0.4	8.16	....	Ditto.....	Ditto.
7	0.21	11.5	....	Coloration of individual small grains at the grain boundaries	Ditto.
8	1.46	1.1	....	None.....	Secondary cementite colored blue; pearlite light yellow.
9	1.0	1.37	....	None.....	Ditto.
10	1.25	....	0.8	None.....	Cementite lamellae in the pearlite colored yellow to blue.
11	1.15	....	1.2	None.....	Ditto.
12	0.8	4.1	12.2	Small and large carbide grains colored.	Same as for cold reagent, but deeper coloration.
13	0.7	4.0	19.0	Ditto.....	Ditto.

This reagent is not satisfactory for pig iron, carbon and Ni:Cr steels.

Recent Chemical & Metallurgical Patents

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Electrical Heating Alloys.—An electrical heating element made of alloy steel containing iron, chromium, silicon and cobalt has been patented by Percy A. E. Armstrong, of Loudonville, N. Y. The chromium content of this alloy can be varied up to 30 per cent, the silicon to 7 per cent and the cobalt to 5 per cent. It is claimed that the alloy has considerable resistance to oxidation and to acids and similar corrosive agents. It therefore appears to be adapted for heating corrosive liquids. (1,385,740; July 26, 1921.)

Production of Ethyl Alcohol From Coke-Oven Gas.—Byproduct coke-oven gas or other gas containing ethylene and from which the tar, ammonia and light oils have been removed is treated to remove hydrogen sulphide, water and carbon dioxide, and is then scrubbed by causing it to bubble through hot concentrated sulphuric acid. The ethyl hydrogen sulphate resulting from the ethylene is withdrawn from the scrubbers, while the gas passes to the distribution mains for commercial use. By mixing the ethyl hydrogen sulphate with a definite quantity of water and subjecting the mixture to heat for a predetermined length of time, the requisite conditions are obtained for the formation of alcohol. The reaction yields its maximum production of alcohol when the mixture is heated in a closed vessel under a temperature ranging between 100 and 120 deg. C. The reaction develops rather slowly but is ordinarily completed in 50 to 60 minutes. It appears that the process has formerly been carried out without allowing the requisite time for completing the reaction and there has been no control or limitation of the volume of water or steam added. As a result of the latter practice, the relatively small quantity of alcohol formed was usually greatly diluted, hence recovered with more difficulty. It is proposed to limit the volume of water to 50-70 per cent of the combined volume of acid and sulphate.

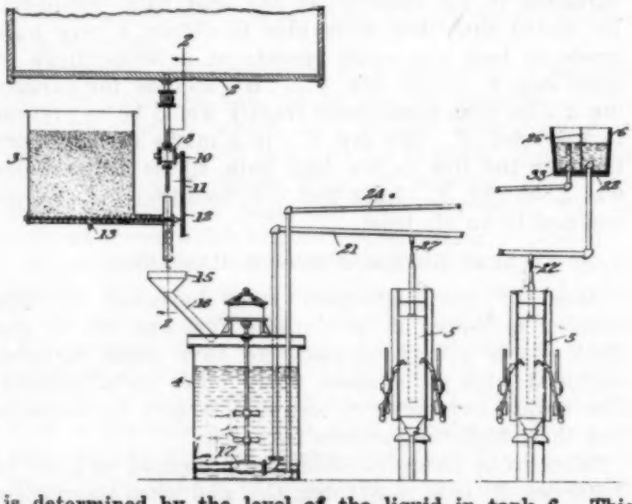
Another important factor bearing on the yield of alcohol is the concentration of the ethyl hydrogen sulphate in the scrubbers. In the process described in this patent, the acid is withdrawn when the ethyl hydrogen sulphate reaches a concentration between 10 per cent and 20 per cent by weight of the sulphuric acid. When this concentration exceeds 30 per cent, the subsequent dilution and treatment of the concentrated ethyl hydrogen sulphate produce ether in substantial quantity, which increases with the concentration of the ethyl hydrogen sulphate. (1,385,515; Cleburne A. Basore, of Auburn, Ala., July 26, 1921.)

Process and Apparatus for Electrolysis of Sodium Chloride Solutions.—According to a recent invention of A. H. Hooker, an aqueous solution of sodium chloride carrying an excess of salt in the solid phase is introduced into the electrolytic cells in constant volume per unit of time. The quantity of salt thus supplied in solid phase is not quite sufficient to maintain the brine within the cell in a saturated condition at the operating temperature. In the past it has frequently been proposed to add an excess of solid salt, or to maintain a permanent supply of such salt within the cell, but it is well known that under such conditions the diaphragm will rapidly become clogged. In the present process the brine within the cell is kept safely below the saturation limit.

In the accompanying drawing 2 is the brine storage tank, 3 the salt hopper, 4 the mixing and agitating tank, 5 the electrolytic cells and 6 the level regulating device. The brine flowing through the power-driven metering device 8 is directed over the end of the worm conveyor 13, where it washes the salt out of the worm as fast as it is fed forward and carries it through the screen 15 and chute 16 into the mixing tank. There is, therefore, in the operation of this device a fixed relation between the displacement of the brine meter and the salt feed. This ratio may be adjusted by the proper choice of sprockets 10 and 12.

By means of the pump 17 and the pipes 21 and 24 a rapid circulation of the salt suspension is maintained. The mixture in the tank is therefore kept in violent agitation and the undissolved salt is maintained in suspension during its flow to the level regulating tank 6 through pipe 21 and its return through pipe 24.

Above each cell 5 is provided a feeding orifice or nozzle 27 of special design. The hydrostatic head upon this orifice



is determined by the level of the liquid in tank 6. This may be adjusted as desired by changing the effective height of the overflow pipe 33. As long as the level in the tank 6 is maintained constant, a uniform quantity of brine carrying with it any desired excess of suspended salt is fed into the cells. The circulating system and the means employed for maintaining the uniform feed are covered by patent 1,388,474 issued to Thomas L. B. Lyster and Kenneth E. Stuart of Niagara Falls, N. Y., assignors to Hooker Electrochemical Co. (1,388,466; Aug. 23, 1921.)

Book Reviews

METALLURGIE GENERALE. By *Léon Guillet*, 528 pp., with 335 illustrations. Paris, France: J. B. Bailière et Fils. Price 40 fr.; bound, 50 fr., 1921.

The publishing house of J. B. Bailière et Fils of Paris has undertaken to publish a technical encyclopedia which will be grouped into five classes—namely, Mining and Metallurgy, Electricity, Mechanics, Civil Engineering, and Chemistry, comprising respectively 43, 35, 30, 30 and 54 volumes, each volume to contain from 300 to 700 pages. This great work is to be carried out under the editorship of Léon Guillet for Mining and Metallurgy, André Blondel for Electricity, Léon Lecornu for Mechanics, A. Mesnager for Civil Engineering and Camille Matignon for Chemistry.

The collection of 192 volumes is to be published under the auspices of the Société d'Encouragement pour l'Industrie Nationale, the Society of Civil Engineers of France, the Union of the Mining and Metallurgical Industries, the Union of the Electrochemical Industry, the Society of Chemical Industry, the Hydrotechnic Society and other scientific and industrial institutions.

The fifty-four volumes devoted to chemistry are:

Thermochemistry
Chemical Equilibrium
Raw Materials in the Chemical Industry
Heating and Power in the Chemical Industry
Installation of Chemical Plants
Installation of Chemical Laboratories
Patents and Trade Marks
Material Handling
Crushing, Pulverizing
Mixing and Agitating
Filtration
Concentration, Evaporation, Drying
Mineral Acids
Industrial Bases
Potash
Sodium Nitrate
Phosphates
Electrochemistry
Electrometallurgy
Minor Chemical Industries
Precious Metals
Lime, Cement
Glass
Ceramics
Porcelain
Metallurgical Analysis of Iron
Combustibles and Their Distillation
Coal-Tar Distillates
Petroleum
Paints
Varnishes
Powder and Explosives
Perfumes
Plastic Materials
Bleaching
Fats
Cellulose and Paper
Oenology
Brewing
Distillation
Sugar
Rubber
Tanning Extracts
Tanning
Resins
Food Products (2 vols.)
Colloidal Chemistry
Pharmaceutical Products
Dyes
Waste Disposal
Fertilizers
Refrigerating
Chemical Industry Hygiene

Of the forty-three volumes devoted to mining and metallurgy the following thirty-three volumes are devoted to metallurgy:

General Metallurgy
Fuels
Refractories
Pig Iron
Bessemer Steel
Open-hearth Steel
Crucible and Electric Steel
Ferro-Alloys
Properties and Uses of Ordinary and Special Steels
Copper, Lead and Nickel
Zinc, Tin, Antimony and Mercury
Aluminum, Magnesium, Sodium and Calcium
Gold and Silver
Platinum Group Metals
Radium
Metallurgical Physics
Metallurgical Chemistry
Testing Metallurgical Products
Chemical Analysis of Metallurgical Products
Thermal and Chemical Treatments
Welding and Soldering
Electroplating
Forging and Rolling of Steel
Forging and Rolling of Metals Other Than Steel
Casting
Drawing
Machining
Foundry (2 vols.)
Installation of Metallurgical Plants
Technical Organization of Metallurgical Plants
Commercial Function of the Metallurgical Industry
Economic Situation of the Metallurgical Industry

Métallurgie Générale, by Prof. *Léon Guillet*, is the first of the series on Metallurgy. This volume of 528 pages with 335 illustrations deals specifically with generalities on the extraction and refining of metals. It comprises twenty-one chapters, the following being a brief outline of the subject covered by each chapter:

In the chapter on classification of metallurgical operations (pp. 1-11) he defines the dry, wet and mixed processes and mentions their application to some of the most important ores.

Roasting and calcining are described under two main classes—namely, those without and with chemical modification (pp. 12-32).

In the chapter on physicochemical laws in roasting and calcining (pp. 34-67) after enunciating Berthollet's eight laws on thermochemistry and the principle of maximum work, he dwells at length on Le Chatelier's thermodynamic laws as applied to metallurgy. The practical applications of these laws are described and are also diagrammatically illustrated.

After a brief description of the classification of the roasting and calcining apparatus, according to the fuel used (solid, pulverized, liquid and gaseous) and of the two main types—namely, direct heating and reverboratory (including electric heating)—(pp. 68-86) he describes and illustrates the most modern apparatus used under the two main classes of roasting and calcining without and with chemical modification (pp. 87-138) and concludes with a concise discussion on the selection of the appropriate apparatus (pp. 130-140).

Like roasting and calcining, fusion is described under the two main classes—namely, without and with chemical modification (pp. 141-200).

The chapter on the physicochemical laws applied to fusion (pp. 201-249) contains discussions and diagrammatic illustrations of fusion with the formation of two liquid layers and of fusion with one liquid and one solid layer. Classical equilibrium diagrams of alloys and reducing fusion with gaseous and solid reducing agents are also discussed.

Chapter VII contains a well-illustrated description of the different types of modern fusion apparatus and also concise outlines of charging and pouring for the different furnaces (pp. 250-313).

Vaporization is described under the two headings of vaporization without and with chemical modification (pp. 314-320). The physicochemical laws of vaporization are touched only briefly (pp. 321-322). The description of volatilization apparatus (pp. 323-335) is limited mostly to mercury and zinc furnaces, with brief mention of special furnaces for distilling alloys and amalgams.

The chapter on electrometallurgy (pp. 336-353) describes the principles of electrothermic operations without and with chemical modifications, giving also brief outlines of the applications to electric pig iron, alloys and aluminum.

In chapter XII he outlines and illustrates profusely the different types of modern electric furnaces and their adaptability for particular uses (pp. 354-384).

Chapters XIII (pp. 385-396) and XIV (pp. 397-416) deal with metallurgical wet method—namely, solution, precipitation and amalgamation—and with the apparatus used in these operations.

Chapters XV (pp. 417-430), XVI (pp. 431-443) and XVII (pp. 444-452) deal with electrolysis with insoluble and soluble anodes, with the physicochemical laws of electrolysis and with the electrolytic apparatus.

Chapter XVIII (pp. 453-468) summarizes the appropriate treatment for native metals and for the main groups of ores such as: oxides and carbonates, silicates, sulphides and arsenides.

Chapter XIX (pp. 469-489) describes pouring methods, faults of ingots and industrial methods used for improving the quality of the ingots.

Chapter XX (pp. 490-499) deals with the classification, properties and uses of metallurgical slags.

In the last chapter the author passes briefly in review the utilization of metallurgical gases, their purification, especially by the application of the Cottrell process, and the utilization of the precipitated dust.

Of special value are the chapters on the metallurgical apparatus, in which he dwells mainly on the most recent practice, and the chapters on the various physicochemical laws as applied to metallurgy, in which he has embodied the theories and practical conclusions of the past and present leading metallurgists.

The long experience of Mr. Guillet as professor of metallurgy and as editor of the *Revue de Métallurgie* has enabled him to give in this introductory volume a clear insight of the metallurgical art and of its present status.

J. S. NEGRU.

Current Events
in the Chemical and Metallurgical Industries

More Plants Increasing Operations

Rubber. The Kelly-Springfield Tire Co., Cumberland, Md., is arranging to place its local plant on a full-time operating basis at an early date, replacing a 4-day schedule operative for some time past. Employment is now being given to close to 1,000 workers as compared with a normal force of 1,165 men, and operatives now on furlough will be taken back gradually.

The Miller Rubber Co., Akron, Ohio, is increasing production at its plant, and since the first of the month about 2,000 employees have returned to the mills.

The Goodyear Tire & Rubber Co., Akron, Ohio, is planning for the resumption of a three-shift basis of production at its plant by Jan. 1. Night shift operations will be resumed at an early date.

The Stanwood Rubber Co., Newark Ave., Elizabeth, N. J., recently reorganized, is planning for the resumption of operations at the local plant on Jan. 15, following a shut-down of a number of months. Improvements will be made and machinery set up at once.

The Firestone Tire & Rubber Co., Akron, Ohio, is increasing operations and adding to its working force.

Ceramic. Practically every general ware pottery at Chester, W. Va., and vicinity is now being operated at capacity.

The McNicol Pottery Co., Clarksburg, W. Va., is increasing production to handle a volume of new orders.

The Briggs Co., Grand Ledge, Mich., manufacturer of facebrick, is developing record production at its plant, now averaging from 40,000 to 42,000 bricks per day. The company during the last month shipped more material than in any other similar period, totaling over 1,250,000 bricks. Advance orders are said to aggregate in excess of 800,000 bricks.

Glass. The Macbeth-Evans Glass Co., Marion, Ind., has resumed operations at its local plant, giving employment to about 500 operatives, or approximately 60 per cent of normal. The men will work in three 8-hour shifts. Additional employees will be added gradually to the force.

The Millville Bottle Works, Millville, N. J., is operating one plant at full capacity, and work will be commenced on a new factory for increased production at once.

The Mount Jewett Window Glass Co., Kane, Pa., controlled by the Interstate Window Glass Co., has been placed in operation, following a shut-down for almost a year past. Employment will be given to about 350 persons. The plant has been improved during the idle period. This is the seventh plant of the Interstate company to be placed in operation.

Iron and Steel. The Parryville (Pa.) Blast Furnace is arranging for immediate blowing in, following a shut-down for the past 6 months. More than 200 men will be employed.

The Lufkin Foundry & Machine Co., Lufkin, Tex., one of the largest industries in that section, will soon resume production on a full-time basis, following a curtailment for some time past.

The Midvale Steel & Ordnance Co., Philadelphia, Pa., is operating its different plants on an average of 50 per cent of normal, with bulk of activity at the Cambria mills.

The Harrisburg Pipe & Pipe Bending Works, Harrisburg, Pa., is operating at full capacity in the steel department at its works. In other branches production is now around 80 per cent, with prospects of early increase.

The Jones & Laughlin Steel Co., Pittsburgh, Pa., is now operating seventeen mills at its Woodlawn, Pa., works, for the first time in several months. A number of the mills resumed on Dec. 6.

Tin Plate. The American Sheet & Tinplate Co., Martins Ferry, Ohio, has placed four more mills in operation, making nineteen mills in service at the present time out of a total of twenty-three. The company has placed every hot mill in operation at its New Castle, Pa., plants for the first time in more than a year, bringing the production up to a point of 100 per cent, or sixty mills. Several hundred additional men are being employed. This schedule of operation will be continued for an indefinite period.

Peat Gasoline Process Declared Fraud

In the case of Doolittle vs. Enricht, the trial of which was discussed at some length on p. 1109 of our Dec. 14 issue, the plaintiff was awarded the full amount invested in stock of the Enricht Peat Gasoline Co., Inc., plus interest.

In making his charge to the jury, Judge Lewis J. Smith stated that the main point in the case was whether or not Mr. Enricht could produce gasoline from peat by his process. To find for the plaintiff the jury would have to satisfy itself that representations were made, that they were fraudulent and that the defendant knew they were fraudulent. The measure of damage would be the amount paid by the plaintiff, $1,000, less the present value of the stock, plus interest. Accordingly the verdict means that in the jury's opinion, the process was a fraud and that the stock is worthless.

During the latter part of the trial it was brought out that the suction-pressure pump was not produced in court with the rest of the apparatus but remained in Mr. Enricht's car until demanded by the experts. They noticed a piece of metal tubing on the piston rod of the pump which limited the stroke and demanded that the pump be taken apart. Mr. Enricht said that this was not possible. Then followed the peculiar actions noted last week which make it appear probable that gelatine capsules of some sort containing gasoline were concealed in the base of the pump, although this was denied by the defendant. In view of these facts at the conclusion of the trial, the attorney for the plaintiff moved that Mr. Enricht be held for perjury and contempt of court. This was denied because of a pending criminal action but the judge granted a motion by the District Attorney to increase the bail and fixed the sum at $10,000, stating that Mr. Enright had disobeyed the order of the court and that consequently he was not disposed to feel lenient. Mr. Enricht went to jail while the bail was being obtained.

New Oil Companies Organized

During the month of November, a total of seventy-one new companies was organized in different branches of the petroleum industry, with a capitalization of $50,000 or larger. The total indicated investment was $60,129,000, as compared with $83,450,000 in the preceding month of October, and $266,190,000 in the corresponding month of 1920. The aggregate indicated investment for the 11 months of the present year stands at $1,190,042,600, divided among 878 companies, as against an amount of $2,677,134,700 for the same period of 1920, representing the gross capitalization of 2,418 companies formed in this time.

Chemical Companies Organized

During the month of October thirty-five new compaines were organized with a capital of $50,000 or more, to engage in the chemical and affiliated industries, with indicated capitalization of $6,300,000 for all organizations. This compares with the formation of twenty-six such companies in the preceding month of October, with a combined capitalization of $6,675,000. In the same month of a year ago, the indicated capitalization of new companies was $50,050,000. For the 11 months of the present year, the total indicated investment in new chemical companies stands at $104,815,000, as against $230,517,000 for the same period of 1920.

Marshal Foch Made Honorary Member of Engineering Societies

Extolled as a fellow engineer who has "directed a greater mass of human energy than any other man," Marshal Foch, at an elaborate ceremony Dec. 13, significant of the advancing movement to promote international peace through the furtherance of engineering ideals, was placed at the head of the honor roll of the organized engineering profession of the United States. In electing Marshal Foch to honorary membership in the four national engineering societies the engineers broke all precedent. The organizations whose governing boards unanimously conferred this distinction upon Marshal Foch were the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers and the American Institute of Electrical Engineers.

The ceremonies were held in the auditorium of the Engineering Societies Building. J. Vipond Davies, president of the United Engineering Society, presided and made a four-minute speech, after which Colonel William Barclay Parsons delivered an address in French. Formal presentation of the certificate of honorary membership was made by G. S. Webster. Marshal Foch responded in part as follows:

> It was due largely to engineering and the engineering industry that the war was brought to a successful conclusion. To the engineering profession also we are indebted for many great lessons which will be vital to mankind in the future. The armies could not have done a great deal without the effort of the engineer. Success was made possible to a great extent by the industry of the people at home, but when it become a question of decision, when the decisive moments arrived, the engineer stood out as an essential factor in complete triumph. What would have become of the armies without the technical training, without the professional knowledge, which you have exercised for the Allies and which enabled us to lead our armies in the field, to feed them, to protect them, and to facilitate their advance quickly and decisively? It is for these reasons that I am pleased to find you here today, to receive from you so splendid a welcome and to express my gratitude and the gratitude of France, as well as the recognition of my countrymen for the tremendous sacrifices made by you and the men of your calling. I am grateful to you for including me in your ranks as a member of the four great engineering societies of the United States. Believe me, this honor which you have conferred upon me I indeed appreciate and I shall cherish this event with the happiest memories.

Safeguarding Fumigation With HCN

The great drawback to the use of hydrocyanic acid gas has been offset, it is believed, by an achievement of the chemists connected with the Chemical Warfare Service. Since hydrocyanic acid gas possesses the quality of killing the eggs of vermin, in addition to being a very powerful disinfectant, it is held by the United States Public Health Service to be the most effective disinfectant which can be used for a variety of purposes. It finds one of its chief uses in the disinfecting of ships. The chief objection of its use has been the fact that it has no smell or taste and produces no discomfort when breathed. As a result a person breathing it it has no warning until he collapses. This has led to many casualties. The Chemical Warfare Service, however, has found that by adding tear gas to hydrocyanic acid gas ample warning is given of its presence. The effect of tear gas is felt instantly, whereas hydrocyanic acid gas must be breathed for several minutes before there are serious results. The experiments indicate that the admixture of tear gas will make possible an extended use of this valuable disinfectant.

Bureau of Mines Increases Chemical Staff

The Bureau of Mines has authorized the employment of a chemical engineer to assist in its non-metallic work. He will be stationed at Reno, Nev. Two chemical engineers are to be added to the staff of the ceramics station at Columbus to do work on cement.

Factory Waste Legislation Not Imminent

No legislation attempting to deal with the pollution of streams will be recommended by the House Committee on Rivers and Harbors until after a thorough study has been made of the question. The committee expects to recommend legislation after the holidays intended to meet the oil nuisance caused by the discharge of petroleum wastes by ships. The committee probably will recommend that the Department of Commerce and the Chief of Engineers make a special study of the alleged injurious effects of wastes from chemical and other manufacturing plants, before undertaking to suggest legislation.

This conclusion was influenced in no small degree by the testimony of Secretary Hoover and by that of John I. Tierney, secretary of the Manufacturing Chemists' Association. Mr. Hoover urged strongly that present legislation be confined to the petroleum nuisance. An excerpt from the argument which was presented by Mr. Tierney is as follows:

> Any consideration of the question of factory waste must take into account local conditions. A manufacturing plant may be the sole or principal support of a community, but would Congress be justified in closing its doors because its effluent made an angler's holiday afternoon less thrilling? That question was put to the Supreme Court of Pennsylvania and the court decided that operation of the coal mines contributed more to the general welfare than did fish life in the rivers affected. Whenever the problem arises in the interior the community in which the factory is situated may be depended upon to work out a solution much more satisfactory than could Congress, and Congress would do well to leave to the city councils and to the state legislatures the framing of ordinances and statutes to control in the particular cases needing attention. Indeed, it is a serious question whether Congress has the power to include the streams of the interior in any legislation upon this subject. The Supreme Court has determined time and again that the federal government has no ownership of, or jurisdiction over, non-navigable streams of a state, and that it has only a negative power as to the navigable rivers, which may be exercised only to prevent obstruction to navigation.
>
> If Congress, nevertheless, enacts a law to prohibit plants located on navigable rivers discharging their effluents into the waters, while it is powerless to enforce similar prohibition as to factories on non-navigable streams, there will result unequal conditions among competitors in the respective industries. The practical aspects of the question, as well as the provision of the Constitution and the rule of law, should convince Congress that the safest and wisest course is to leave to the city councils and to the state legislatures the solution of this industrial problem, at least to the extent that it exists in the interior. And as stated above, information concerning the relation of factory waste to the pollution of harbor waters is so meager and uncertain that the wiser plan would be for Congress to direct an investigation to be made of that phase of the problem before drafting a measure to deal with it.

Regulations for Transportation of Carboys

The regulations for the transportation of containers which have been used in the shipment of flammable or other dangerous articles have been amended by the Interstate Commerce Commission so as to read as follows:

> Empty cylinders, barrels, kegs or drums, previously used for the shipment of an inflammable, poisonous, or corrosive gas or liquid, must have their filling and vent holes properly closed. They should be loaded in open or stock cars when practicable. Labels are not required on such packages and cars should not be placarded, but lighted lanterns or other open-flame lights should be kept away.
>
> Carboys previously used for the shipment of corrosive liquids, when presented to carriers for transportation in carload and less-than-carload shipments as "empty carboys," must be thoroughly drained. Whenever practicable they should not be loaded in cars containing valuable or perishable freight.
>
> Empty bottles previously used for the shipment of nitric acid or nitric acid mixtures should be securely stoppered.

November Meeting, Deutsche Chemische Gesellschaft

The November meeting of the Deutsche Chemische Gesellschaft took place as usual in the lecture hall of the society building, the well-known Hoffmann House, Berlin, on Monday, Nov. 14. It was promptly opened at 7.15 p.m. by President C. Harries, the synthetic rubber chemist.

The deaths of the following members were announced: Dr. Fr. Stockhausen, of the Deutsche Gold & Silberscheideanstalt, in Frankfurt a-Main. Dr. Erich Kunheim, of Kunheim & Co., Niedenschönweide-Berlin.

Prof. Gabriel, of the Chemische Institut of the University of Berlin, who was present at the meeting, was officially congratulated on his seventieth birthday by the president in the name of the society.

The first paper was read by Dr. Hermann Mark, who offered his work on penta-arylethyls in defence of trivalent carbon. Prof. Schlenk, the present head of the Chemische Institut of the University of Berlin and successor to the famous Emil Fischer, helped to support the theory, which was first announced in 1900 by the American chemist Gomberg, that carbon, although usually tetravalent, can also exist in a trivalent state. All compounds with trivalent carbon are very unstable and highly colored. While in the past only the tri-arylmethyls were known, W. Schlenk and the speaker succeeded in producing the homologs of penta-arylethyl. Hereby a new and interesting proof of the existence of trivalent carbon was brought to light. An interesting debate followed between the president and Dr. Mark.

The second paper was read by Dr. Hans Enders, on "The Effect of NO on Sodiumalkyls." This interesting substance NO, in which nitrogen must be considered bivalent, acts upon metallo-organic compounds in two stages. Through this reaction, addition products are formed which are of special interest, as they can be considered as substitution products of hyponitrous acid HN_2O_2R. W. Schlenk and the speaker succeeded in isolating three different reaction products, whereby three isomers were secured. These three isomers were demanded by the theory of structural valence and the experimental proof of their existence reinforces anew the stereochemistry of nitrogen. In the discussion which followed Prof. P. Jakobson, the author of the well-known "Lehrbuch der organischen Chemie," the president and the speaker took active part.

The third paper was delivered by Dr. E. Tiede on "Phosphorescent Magnesium Sulphide." Up to now the only sulphides of the alkaline earths which served in the production of luminous paints were those Ca, Sr and Ba. The speaker has now also succeeded in producing pure magnesium sulphide through the use of ingeniously devised apparatus and the exercise of extraordinary experimental care, and he has shown that this alkaline earth sulphide is very well adapted to the production of phosphorescent materials. These new phosphorescent substances are easily excited by ultraviolet light and they shine particularly long and brightly.

The three lectures were well illustrated with lantern slides and with experimental proofs and demonstrations. The latter could be performed to great advantage on the excellently equipped lecture table of the Hoffmann House. The demonstrations of the many variously excited phosphorescent materials by the last speaker met with most enthusiastic applause.

Bibliography on Refractories

The Refractory Division of the American Ceramic Society has issued a new bulletin in the form of a bibliography of magnesite and dolomite refractories. Organizing Secretary Ross Purdy, Columbus, Ohio, has collaborated with A. S. Greaves-Walker, chairman of the division.

This is but the first of the bibliographies to be issued by the society. The Refractory Division will shortly issue other bulletins on chromium, sillimanite, alumina, spinel, silicon carbide, zirconia, carbon, clay and special refractories including nitrides and oxides. The U. S. Bureau of Mines, in Columbus, is collaborating in the preparation.

Spread of War Gases Subject to Control

In view of recently published statements that gas should be outlawed as a weapon of warfare because it would drift away from the actual scene of conflict and endanger civilian communities at a distance from the battlefield, General Amos A. Fries, the head of the Chemical Warfare Service, has authorized the following statement:

> Chemical warfare gases can be confined in war to the fighting forces practically to the same extent that the action of high explosives, shells and bombs can be confined. There is a widespread feeling that even a small quantity of gas loosened in a terrritory is dangerous for long distances. This is absolutely incorrect. The most powerful gases of today volatilize so slowly that their effects will be felt only a few hundred yards from where they are dropped.
>
> The idea that gases would be dangerous to surrounding populations for long distances arose from the early cloud gas attacks. To produce a cloud that would drift, say, 6 miles, would require 20 lb. or more of liquid gas per foot of front (or about 53 tons per mile) 2 miles or more in extent. Such concentrations will never be attempted except in the face of the enemy where the chances of inflicting heavy losses among his soldiers are worthy of the attempt.
>
> The use of gases against crossroads, railroad centers, camps and the like would be of the mustard gas variety, due to the lasting qualities of those gases. Thus a bombardment with shells every 2 to 5 days would make the place dangerous for every man working in the area bombarded unless continuously protected by masks and gasproof clothing. The danger area, however, would extend but very little beyond the immediate area at any time, and hence would affect the immediate area and that area only.

American Foundrymen's Association to Meet in Cleveland

The city of Cleveland has been selected as the place of the next convention and exhibit of the American Foundrymen's Association, to be held during the week of April 24, 1922. The association headquarters and exhibits will be in the new Cleveland Public Hall, at Lakeside Ave. and East Ninth St., which is rapidly nearing completion. The Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers has announced that it will hold joint convention with the Foundrymen, as has been the custom in years past.

Of the cities considered, Cleveland is most centrally located for the membership, for the foundry industry and for the manufacturers of foundry equipment and supplies, who make annual exhibits, and its selection will conserve traveling and freight expense.

Following an interval of 18 months the next meeting promises to be of unusual interest and profit. The papers committee advises that manuscript copies are being received and that the first set of preprints of papers to be presented at the convention will be mailed out in January.

There never was a period when economy in production counted for so much as now. At the coming exhibit will be displayed all the latest improvements and inventions in foundry equipment.

Synthetic Camphor Factory May Resume Operations

Plans for the resumption of operations in the synthetic camphor factory of E. I. du Pont de Nemours & Co., Inc., at Deepwater Point, N. J., have been under discussion recently by large consumers of this product and officials of the du Pont company. The Deepwater plant has a capacity large enough to meet the requirements of the pyroxylin plastic manufacturers of the United States. These manufacturers were represented at the conference by N. M. Clark, vice-president of the Celluloid Company; H. R. Bemis, treasurer of the Fiberloid Corporation, and B. W. Doyle, treasurer of the Viscoloid Company.

Fire Caused by Sodium Peroxide

The analytical laboratory of the Central Scientific Co. of Chicago was recently badly damaged by fire started by a hundred pounds of sodium peroxide.

Plan to Avoid Duplication in Collecting Metal Statistics

The metal producers are having their interests made a matter of special consideration in connection with the biennial census of manufactures. Secretary of Commerce Hoover and Secretary of the Interior Fall have instructed Eugene F. Hartley, chief statistician of manufactures, and Dr. George Otis Smith, director of the U. S. Geological Survey, to recommend a plan to obviate duplication of government effort and to prevent unnecessary burdens on smelters and other sources of information required for the compilation of the statistics. The proposal which probably will be recommended to the two secretaries is that the Geological Survey, by reason of its constant touch with the mineral industry, act as the agent of the Bureau of the Census every two years and collect the special data desired at the time the figures of annual production are collected for the Survey's own use. It is the expressed desire of both Secretaries Fall and Hoover, each of whom knows the mining business from the inside, to make as few demands upon the accounting offices of the mining companies as is possible.

River Terminals Needed for Steel Shipments Into Cincinnati

Recent shipments of iron and steel from Pittsburgh and various cities along the Ohio River which have the necessary terminals have caused much comment among local business men, the products carried on these trips not being available to Cincinnati because of the difficulty of transferring them from barges to trucks or other vehicles. With proper terminal facilities much business that now goes to other cities would come to Cincinnati and at the same time local consumers would get the benefit of the lower space rates offered by the waterway carriers.

Several plans for terminals have already been worked out by engineers, and it is expected that early action will be taken to build river terminals at some advantageous point on the river front to take care of the ever-increasing shipments of heavy bulk freight into the city. The Chamber of Commerce is active in promoting a concerted effort to this end among the business interests.

Fertilizer Manufacturers Organize

Fertilizer manufacturers in the Del-Mar-Via Peninsula district, Maryland, are organizing an association to include all such interests throughout this section, to be known as the Peninsula Fertilizer Manufacturers' Association. Details of the new organization were perfected at an informal meeting at Salisbury, Md., Nov. 28, at which William B. Tilghman of the William B. Tilghman Co., Salisbury, was elected temporary chairman; E. Benson Dennis, of L. E. P. Dennis & Co., Crisfield, Md., vice-chairman; and William E. Valliant, Valliant Fertilizer Co., Georgetown, Del., temporary secretary. A meeting will be held soon to effect a permanent organization. Those represented in the new association include: William B. Tilghman Co. and the Farmers' & Planters' Co., both of Salisbury; L. E. P. Dennis & Co., Crisfield; Huston, Darby & Co., Seaford, Del.; Dorchester Fertilizer & Lime Co., Cambridge, Md.; W. H. Valliant & Bro., Bellevue, Md.; E. S. Valliant & Sons, Centerville, Md.; Worcester Fertilizer Co., Snow Hill, Md.; and the Valliant Fertilizer Co., Georgetown, Del.

Lehigh Valley Chemical Society Elects Officers

At a meeting of the Lehigh Valley Section of the American Chemical Society, held in Gayley Hall, Lafayette College, Easton, Pa., Dec. 1, the following officers were elected for the ensuing year: Chairman: P. R. Croll, New Jersey Zinc Co., Palmerton, Pa.; secretary and treasurer: H. A. Depew, New Jersey Zinc Co., Palmerton; first counselor: Dr. E. C. Bingham, Lafayette College; second counselor: Henry Wysor, Easton. The principal address of the evening was made by Dr. Charles L. Reese, research director, E. I. du Pont de Nemours & Co., Wilmington, Del., on the subject, "The Effect of Maintenance of the Dye Industry on Scientific Development in This Country."

Notes on Industrial Activities in Maine

Work on new construction for the Advance Bag & Paper Co. at Howland, Me., is progressing rapidly, about 200 men being employed at present. Crews of men have been working day and night on the coffer dam to enclose the site of the power house extension, which will increase the power production greatly. The new machine room will be 52 x 288 ft. New beater, Jordan and slusher rooms are also being built. Two 750-hp. boilers and a 400-ton overhead bunker are to be added to the power plant. The bag mill will be 150 x 65 ft., four stories high, and will house sixty modern bag machines. The new concrete dam, built last year in the Piscataquis River near its confluence with the Penobscot, will provide a supply of water for power for many years. The improvements will increase the paper production by about 48 tons daily and it is expected that there will be an output of over 2,000,000 bags daily.

The Bowdoin mill of the Pejepscot Paper Co., one of its six newsprint mills located at Topsham, Me., was shut down recently. This mill was formerly owned by the Cowles interests and it is believed that they are endeavoring to recover control of it.

Evidence on Dec. 1 indicates that the strike at the International Paper Co. mills at Livermore Falls is about at an end. The strike started May 1. Manager Murray states that eight of the machines at Livermore Falls are running. Eight machines of the same company at Palmer Falls and the sulphite mill at Chisholm are also in operation. The Webster mill of the International Paper Co., at Orono, Me., is now running on a normal production basis. The strikers have gradually returned or have been replaced.

The chemistry department of the University of Maine and the Maine Section of the American Chemical Society, under the direction of Dr. C. A. Brautlecht, have been showing moving pictures of chemical and metallurgical industries weekly. The films are those furnished by the Bureau of Mines and some of the leading industrial corporations.

Renewed activity in the building trades is causing an interest in the slate quarries near Brownville, Me. L. F. Johnson is temporary chairman of the newly organized board of trade of that town. Various concerns are investigating both the large masses of high-quality unquarried slate and the hills of accumulated waste near each quarry. The waste at practically all quarries will undoubtedly soon be crushed, screened and shipped to roofing paper mills as surfacing material and as filler in other industries. The Monson Slate Products Co., a Massachusetts corporation, has purchased one of the Blanchard quarries and is preparing to use some some of this slate, after grinding, for coating asphalt shingles. Blanchard, Brownville and Monson quarries are being watched closely by parties interested in slate. The Monson Slate Products Co. has erected buildings for grinding and sieving waste slate.

Proposed Spanish Tax on the Export of Pyrites

The Huelva mine owners are beginning to protest against the proposed export duty of eight pesetas per ton on pyrites. They say that this duty will mean the ruin of the industry. The defenders of the future régime reply that the restrictions on exports will lead to the establishment in Spain of factories using this product, from which superphosphates, refined copper and sulphuric acid could be obtained.

Chemistry Building at University of Mississippi

The State Bond Improvement Commission, Jackson, Miss., has approved an award of contract to the Doullut & Williams Co., Hibernia Bldg., New Orleans, La., for the erection of a new fireproof chemistry building at the University of Mississippi, Oxford, to cost about $160,000. Theodore C. Link, Director of Public Works, is in charge.

Colorado Clays Exploited

The U. S. Bureau of Standards will shortly analyze samples from clay deposits found in Grand Valley, Col. The local chambers of commerce at Grand Junction and Fruita are hoping to locate clays suitable for the making of brick, pottery and tiling.

Personal

R. L. AGASSIZ, Boston, Mass., has been elected president of the recently organized Copper and Brass Research Association.

WILLIAM T. ASHLEY has resigned as vice-president and general manager of the Hauk Nut Butter Co., Newark, N. J., to devote his time to the exploitation of his patents on a new process of margarine manufacture.

Dr. H. E. BARNARD, director of the American Institute of Baking, has moved his office from Minneapolis, Minn., to the new Institute home, 1135 Fullerton Ave., Chicago, Ill.

Prof. MARSTON T. BOGART, of Columbia University, addressed the Civic Club at Cleveland, Ohio, on Dec. 3, in defense of the proposed selective embargo on dyes. Dr. Bogart's address was in reply to one of the previous week, before the same audience, by a member of the editorial staff of *The Nation*, who attacked the embargo on the ground that it would foster monopoly.

WILLIAM M. BURTON, of the Standard Oil Co. of Indiana, will receive the Perkin Medal at the meeting of the Society of Chemical Industry at the Chemists' Club, New York, Jan. 13, 1922.

L. E. CALKINS, formerly superintendent of the Minneapolis plant of The Barrett Co., and F. SCHILLING, formerly superintendent of the St. Louis plant, are now members of the Chicago plant organization.

Dr. J. CAVALIER, recteur of the University of Tolouse, spoke before the Bureau of Standards scientific staff on Dec. 16 on the subject "Les Industries Chimiques en France pendant la Guerre."

FULLER CLARKSON left the Fixed Nitrogen Research Laboratory on Dec. 1 to become associated with the Procter & Gamble Co. He will study plant problems.

W. H. EISENMAN, national secretary of the American Society for Steel Treating, spoke before the Charleston, W. Va., chapter of the society on "Heat-Treating—Its Past, Present and Future."

H. S. GALE sailed on Dec. 13 for Colombia, where he will be engaged for three months in an oil investigation for an American company.

H. A. HAUPTLI, superintendent of Sears, Roebuck & Co.'s wallpaper mill, has just returned from an extended business trip through several European countries.

H. F. HERRICK, formerly of the National Aniline & Chemical Co., Buffalo, N. Y., has accepted a position as chemist with the American Aniline Products Co., Lock Haven, Conn.

HENRY JOSEPH, who received the degree of chemical engineer last June from Columbia University, has taken up work with the Consolidated Gas Co., as engineering assistant to Mr. Lunn, chief chemist.

Dr. ROBERT S. LANDAUER has accepted the position of research physicist with the Standard X-Ray Co. of Chicago.

W. LEE LEWIS, chemistry director at Northwestern University, is furnishing a new tear-gas bomb to the Chicago Police Department for combating dangerous criminals. It was used as an effective threat in the recent stockyard workers' strike in Chicago.

EDWARD S. LIEBSCHER has resigned as research chemist with the American Lead Pencil Co., Hoboken, N. J., and is now associated with the Far East Products Co., Inc., Brooklyn, N. Y. as president and chemical director.

Prof. A. S. LOEVENHART of the University of Wisconsin spoke on Nov. 17 on "The Relation Between Chemical Structure and Pharmacological Action." He also spoke at Northwestern University.

Prof. CHARLES MOUREU, of the College of France, president of the International Union of Pure and Applied Chemistry, and Prof. A. MAYER, of the University of Strasbourg, the two French chemical advisers at the Limitation of Arms Conference, spoke briefly before the Washington Section of the American Chemical Society on Dec. 8. They presented greetings of French chemists and spoke most encouragingly of their interest in the international relations within the science.

A. PACYNA, formerly control chemist of production at the Chicago plant of The Barrett Co., is now a member of that company's research staff at Shadyside, N. J.

DON STEVENS, formerly with the technical division of the Goodyear Tire & Rubber Co., has accepted the managership of the Okonite Co., Passaic, N. J., manufacturer of insulated cable.

Prof. A. L. TATUM, of the department of pharmacology, University of Chicago, spoke to the Kent Chemical Society of the university on Nov. 10, on "The Equilibrium Between Stored and Circulatory Sugar in the Animal Organism."

MAURICE C. WALSH, who received the degree of chemical engineer from Columbia University last June, is now located at Mellon Institute, Pittsburgh. His work is in connection with the newer devolpments which are extending the uses of container board for packing cases.

Obituary

ARTHUR H. GALLUN, of A. F. Gallun & Sons, Milwaukee, died on Nov. 9, 1921, from an attack of pneumonia. He was associated with the leather industry all his life and worked constantly for a wider appreciation of the value of fundamental chemical research in this field.

Current Market Reports

The Chemical and Allied Industrial Markets

NEW YORK, Dec. 19, 1921.

The general activity of the chemical market during the period under review has shown that business so far is better than in November, but there still remains a pronounced tendency of quietness, owing to the holiday season and the inventory period. It is commonly known that these two influences always work against any temporary activity. Contract business for deliveries to begin after the first of the year is progressing well under adverse conditions and with every indication that January business will be far ahead of recent months. A great deal of readjustment has been going on at chemical plants and it is asserted that prices of many items have been revised to meet the law of supply and demand. Export conditions are gradually improving, and this is fully reflected in the number of inquiries reaching the market from Italy, South American countries and the Orient. The recent rise in foreign exchange, together with efforts now on foot to stabilize money, will go a long way toward stimulating our foreign trade. Prices in second hands show a decided weakness, but producers seem to be firmer in their views. Additional sales of contracts went through in solid caustic soda and soda ash, but spot trading in these commodities remained quiet, with occasional sales noted for export. Prices on spot were a trifle easier owing to the limited extent of inquiries and keener competition existing among second hands. Caustic potash looked slightly weaker. Bichromate of soda held on at former levels, with sales of a small nature from regular consuming channels. Anhydrous ammonia was reduced 1c per lb. by manufacturers after nearly an entire year at the former quotation. Oxalic acid is holding steady, with former prices held by leading sellers. Imported bromides are being offered on spot at prices materially lower than those named by domestic producers. Cream of tartar showed a little more strength and the market closed slightly higher. Makers of cyanide of soda are very firm in their ideas before the announcement of contract prices. Arsenic is quoted lower. Prussiate of soda was practically the only item that furnished excitement in the otherwise quiet market. The reduced spot supplies and the advanced foreign

exchange rates and an active inquiry from the consuming industries all had a tendency to shoot prices upward and the market closed in an exceedingly firm position.

CHEMICALS

Dealers offered solid *caustic soda* at $3.80@$3.85 per 100 lb. on spot and quoted $3.90 f.a.s. The strength in foreign exchange is bringing out more inquiry for export and although sales could not be termed plentiful, moderate orders were reported to Europe, South America and Japan. Producers report sales at $2.75 per 100 lb. and upward for forward shipment, basis 60 per cent, f.o.b. works. There was a slightly firmer feeling noted in *nitrite of soda* on spot. Some dealers were still quoting former figures ranging from 6¾@7c per lb. The inquiry is not showing any pronounced activity and consumers are merely buying actual necessities, which in most cases consist of small quantities. The continual absence of any important orders for additional quantities of caustic potash, 88-92 per cent, has caused a rather easy undertone. Imported material is offered at 5½@5¾c per lb. and it is admitted in some directions that a shade under this figure might be accepted on firm business. Forward shipments are quoted at $5.35@$5.40 per 100 lb. Quiet trading featured the market on *bichromate of soda* and prices have shown no tendency to advance. Sales are reported at 7¾@8c. per lb., with most transactions going through at the lower figure. Contract quotations were held by leading interests at 7¾c per lb. Offerings were not too plentiful, but seemed to be sufficient to meet the current extent of inquiries. *Prussiate of soda* stood alone as the feature of the week's activities. Supplies of imported material have remained in a few scattered hands and with the strength in money rates and the sold up condition of domestic manufacturers, prices on spot were sharply advanced. Sales were reported toward the close of the week as high as 15½c. per lb., with the majority of sellers asking 15¾@16c per lb. for the remaining odd lots. Buyers have not responded as quickly as the rise in prices, but those in need of supplies have to purchase at the present market quotations. Domestic *bleaching powder* is holding firm on the basis of $2.25 per 100 lb. for large containers, f.o.b. works, and at $2.50 per 100 lb. for small drums. Spot offerings of large drums are limited and the market appears quite firm at 2½@2¾c per lb. Imported bleach is quoted at $2.20 per 100 lb. ex-dock, with only scattered lots obtainable. Dealers offered spot *strontium nitrate* at 11@12c. per per lb., depending upon the quantity. Some small-lot sales have been reported, but business in this chemical has shown very little activity. Imported U.S.P. *permanganate of potash* is offered as low as 15½c. per lb., against a manufacturers' price of 22c. per lb. Producers of *cyanide of soda* are firmer in their views. The 96-98 per cent grade is quoted at 30c per lb., although a slightly lower figure could be done on round-lot business. Leading factors in *arsenic* are quoting various prices on spot. Resale merchants want 5½c. per lb. and makers name 6c. per lb. as their lowest.

GENERAL CHEMICALS

CHICAGO, Dec. 16, 1921.

Quieter conditions prevailed in the general chemical market during the past two weeks. This state of affairs is nothing unusual at this time of the year and a pickup can scarcely be expected until after New Year's. There is some tendency on the part of dealers to shade prices on account of the approaching inventory season, but low prices do not appear to tempt the buyer at this time. One large firm has given its salesmen a two weeks' vacation starting on the 19th. This firm reports that it is useless to send out salesmen, as buyers are practically out of the market and will stay out until their inventories are cleared up. All factors seem optimistic over the prospects for next year and expect to enjoy a good volume.

GENERAL CHEMICALS

The situation on alkalis lacks new developments and the spot market is quiet. Ground *caustic soda*, 76 per cent, is quoted at $4.75 per 100 lb. and the solid at $4.10@$4.25. *Soda ash* is moving only in small quantities and is unchanged at $2.60 per 100 lb. in cooperage. *Caustic potash* is quiet and supplies are available in the spot market at 6½@6¾c. per lb. *Potash alum* is firm and supplies are light. The lump is quoted at 5½@6c. per lb. and the powdered at 6½@7c. The demand for *ammonium carbonate* is limited and small spot stocks are offered at 9@10c. per lb. *Bleach* is moving in a routine way at 3@3½c. per lb. for large drums. *Carbon bisulphide* is firm and lacks quotable change at 7@7½c. per lb. *Carbon tetrachloride* is in moderate demand and quotations are firm at 10½@11c. per lb. *Glycerine* was advanced again by refiners and is very firm at 15½c. per lb. for c.p. material in drums. *Epsom salts* are quiet, with supplies of the U.S.P. material offered at 2¾c. per lb. Single *nickel salts* are quoted lower by first hands, the new level being 11c. per lb.

Potassium bichromate is rather slow and supplies are available at 13@13½c. per lb. *Soda bichromate* is scarce, and 8½c. was the best offer noted. *Potassium chlorate* is firm and scarce. The small stocks on spot are quoted at 8¾@10c. for crystals and 8½@9c. for powdered. *Red prussiate of potash* has shown a firmer tendency and is offered at 28½@30c. per lb., according to seller and quantity. *Yellow prussiate* is also firm at 24@25c. per lb. *Salammoniac*, while very firm and scarce, is unchanged at 8@8½c. per lb. for the white granulated. *Bicarbonate of soda* is moving in a routine way at $2.60 per 100 lb. *Sodium fluoride* is rather quiet at 11@12c. per lb. *Hyposulphite of soda* is not moving very well, although the photographic trade continues to purchase small lots. Pea crystals are unchanged at $4.05 per 100 lb. in barrels.

The acid business is dull and prices are unchanged. *Acetic acid* is moving only in small lots and is quoted at 2¾c. per lb. for 28 per cent in barrels. *Glacial acetic acid* business is practically at a standstill, but prices remain the same. *Oxalic acid* is attracting but little attention and supplies are offered at 15@16c. per lb. *Phosphoric acid* is very quiet and the sirupy, 85 per cent, is quoted at 19@21c. per lb. The heavy acids are unchanged as to price and plentiful. *Sulphuric acid* is quoted in tank cars at the works at $18@$20 per ton.

PHARMACEUTICALS

There is a fair volume of business reported from this branch of the trade and practically all prices are firm. *Bismuth* metal advanced again to $1.80 per lb. in 500-lb. lots. No announcement of a change in bismuth preparations came from manufacturers, but it is scarcely possible to maintain the present level in the face of the last three advances on the metal. Mercurials are very firm and are said to be moving in a satisfactory manner. Like bismuth, mercury metal has advanced rapidly of late with no corresponding advance in the preparations. Iodine and all iodides were advanced 30c. per lb. by manufacturers this week. This makes the new level for *potassium iodide* $2.90 per lb. and for *iodine* $3.80. Business on iodides was reported as very good by both first hands and dealers.

VEGETABLE OILS

There is only a routine demand for *linseed oil* and inquiries were reported as light. The boiled oil is quoted today at 69c. per gal. in 5-drum lots and the raw at 67c.

NAVAL STORES

The naval stores market is a rather quiet affair and only small business was reported. *Spirits of turpentine* was offered today at 80c. per gal. in 5-drum lots, but the movement was slow. *Rosins* are slightly lower in price.

The Iron and Steel Market

PITTSBURGH, Dec. 16, 1921.

Under date of Dec. 15 the National Tube Co., issued new price lists, increasing discounts on standard steel pipe, except ⅛-in., 2½ points or about $5 per net ton, also on O.D. pipe, while oil country goods, which are quoted in net prices, were reduced approximately the same amount per ton. Line pipe discounts were increased 3 points. The action of the Steel Corporation subsidiary was taken on account of continued shading by independents, the shading beginning very shortly after the reduced prices of Sept. 16 were issued. Line pipe is usually shaded on large orders, but of late the shading has been very deep, and there have been

a few cases of deep shading in oil country goods. In standard steel pipe the shading was shallow, but had become almost universal. Possibly the shading would have been deeper had not the independents quite generally had price guarantees outstanding, providing a concession on all carload shipments made within 60 days of a general reduction. The shading was generally an extra 5 per cent instead of the 2½ per cent the independents frequently give from the leading interest's prices. Thus the official reduction goes quite beyond the shading.

The most interesting feature of the decline in tubular goods is the test it furnishes to the general rule that finished steel prices are practically stationary now because demand is light and orders are small individually, too small to provoke very active price competition. In tubular goods the demand has been heavier than demand for any other important finished steel product and has represented 70 or 80 per cent of the pipe mill capacity, conservatively estimated. Other steel products show no noteworthy price change in the past week or indeed for several weeks.

Shading in tin plate has spread somewhat and the market is quotable now at $4.65@$4.75 against $4.75 flat formerly quoted. Sheets, on the other hand, are the most rigidly held of any finished steel product, buyers finding it quite impossible to shade 3c on black or 4c on galvanized. The condition is the more remarkable on account of the recent great irregularities in sheet prices.

Bars, shapes and plates remain quotable at a range of 1.50@1.60c., but the lower price is more common. Wire products in general are at prices ruling before the advance of Sept. 12, which proves to have been largely on paper, and there is occasional shading at that.

Pittsburgh Basing

The long-established custom of Pittsburgh basing, or "Pittsburgh plus," the practice complained of months ago before the Federal Trade Commission and on which hearings are to begin next month, is less and less in evidence. The departure is of course due chiefly to the strongly competitive conditions existing when demand is far below productive capacity, but is no doubt encouraged by the high freight rates now ruling. The Pittsburgh basis obtains in sheets and tin plates, but in practically all other commodities there are some cases of departures, by Eastern, Buffalo, Southern and Western mills. Usually the Pittsburgh and valley mills do not meet the special prices thus made, but occassionally they do, thus accepting lower prices f.o.b. their mills than they would receive when selling in nearby territory.

Production

Production is fairly well maintained by the Steel Corporation, while independent mill operations have decreased considerably since the high point early in November, when ingot output was at the rate of about 25,000,000 tons per annum, or 48 per cent of capacity, while the rate now is about 21,000,000 tons or 40 per cent. Unless there is a phenomenal increase in steel demand in the not distant future the present practice of speaking of steel production in terms of percentage of capacity will yield to a style of referring to production in terms of actual tons, the estimated capacity coming to have only theoretical interest. The tonnage concept is much more cheering. Thus the recent rate of about 25,000,000 tons was equal to the production in 1910, when the mills operated substantially at their capacity.

Pig Iron

Foundry pig iron, quotable for weeks past at $20.50 valley, the price gradually becoming nominal, has sold in a few small lots at $19.50, making a more substantial quotation and putting foundry between bessemer, at $20, and basic, at $19, a position that seems more natural. The whole pig iron market remains decidedly stagnant and consumptive requirements are evidently decreased, for a mere "waiting policy" on the part of buyers would not account for the long-continued apathy.

Connellsville furnace coke for spot shipment is quotable nominally at $3 per net ton f.o.b. ovens, a price that would probably be shaded if there were any important inquiry. Spot foundry ranges from $3.75 to $4.50 according to brand.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... –	$0 40 – $0 45
Acetone	lb.	$0 12½ – $0 12½	.13 – .13½
Acid, acetic, 28 per cent	100 lbs.	2 75 – 3 00	3 25 – 3 50
Acetic, 56 per cent	100 lbs.	5 00 – 5 25	5 30 – 5 50
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	10 00 – 10 50	10 75 – 11 00
Boric, crystals	lb.	.12½ – .12¾	.13 – .13½
Boric, powder	lb.	.13 – .13½	.14 – .14½
Citric	lb.	..... –	.44½ – .46
Hydrochloric	100 lb.	1 25 – 1 50	1 60 – 1 75
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.12½ – .13
Lactic, 44 per cent tech	lb.	.09½ – .10	.10½ – .12
Lactic, 22 per cent tech	lb.	.04 – .04½	.04½ – .05
Molybdic, C.P	lb.	3 00 – 3 25	3 30 – 3 75
Muriatic, 20 deg. (see hydrochloric)	....	..... –	..... – .....
Nitric, 40 deg	lb.	.06½ – .06½	.06½ – .07
Nitric, 42 deg	lb.	.06½ – .07	.07½ – .07½
Oxalic, crystals	lb.	.14½ – .15	.15½ – .16
Phosphoric, 50 per cent solution	lb.	.13 – .13½	.14 – .18
Picric	lb.	.20 – .25	.27 – .35
Pyrogallic, resublimed	lb.	..... –	1 75 1 90
Sulphuric, 60 deg., tank cars	ton	..... –	11 00 – 12 00
Sulphuric, 60 deg., drums	ton	..... –	13 00 – 15 00
Sulphuric, 66 deg., tank cars	ton	17 00 – 18 00	..... – .....
Sulphuric, 66 deg., drums	ton	21 00 – 22 00	22 50 – 23 00
Sulphuric, 66 deg., carboys	ton	..... –	..... – .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	21 00 – 22 00	..... – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	23 00 – 23 50	24 00 – 24 50
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	31 00 – 32 00	33 00 – 34 00
Tannic, U. S. P	lb.	..... –	.75 – .85
Tannic (tech.)	lb.	.55 – .60	.61 – .65
Tartaric, imported crystals	lb.	..... –	.26 – .26½
Tartaric acid, imported, powdered	lb.	..... –	.27 – .28
Tartaric acid, domestic	lb.	..... –	..... – .32
Tungstic, per lb. of WO	lb.	..... –	1 10 – 1 20
Alcohol, Ethyl	gal.	..... –	4 65 – 5 00
Alcohol, Methyl (see methanol)	....	..... –	..... – .....
Alcohol, denatured, 188 proof	gal.	..... –	.42 – .43
Alcohol, denatured, 190 proof	gal.	..... –	.43 – .44
Alum, ammonia, lump	lb.	.03½ – .03¾	.04 – .04½
Alum, potash, lump	lb.	.03½ – .04	.04½ – .04¾
Alum, chrome lump	lb.	.07½ – .08	.08½ – .08½
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .02¾	.03 – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .07¾	.08 – .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 – .30½	.31 – .33
Ammonium carbonate, powder	lb.	.07 – .07½	.08 – .09
Ammonium chloride, granular (white salammoniac)	lb.	.06½ – .07	.07½ – .07½
Ammonium chloride, granular (gray salammoniac)	lb.	.06½ – .07	.07½ – .07½
Ammonium nitrate	lb.	.07½ – .07¾	.07½ – .08½
Amylacetate tech	gal.	..... –	2 40 – 2 65
Arsenic oxide, (white arsenic) powdered	lb.	.05½ – .05¾	.06 – .06½
Arsenic, sulphide, powdered (red arsenic)	lb.	.12 – .12½	.12½ – .13
Barium chloride	ton	48 00 – 49 00	50 00 – 55 00
Barium dioxide (peroxide)	lb.	.20 – .21	.22 – .23
Barium nitrate	lb.	.06½ – .07	.07½ – .08
Barium sulphate (precip.) (blanc fixe)	lb.	.04 – .04½	.04½ – .05
Bleaching powder (see calc. hypochlorite)	.....	..... –	..... – .....
Blue vitriol (see copper sulphate)	.....	..... –	..... – .....
Borax (see sodium borate)	.....	..... –	..... – .....
Brimstone (see sulphur, roll)	.....	..... –	..... – .....
Bromine	lb.	.23 – .24	.25 – .28
Calcium acetate	100 lbs.	1 75 – 2 00	..... – .....
Calcium carbide	lb.	.04½ – .04¾	.05 – .05½
Calcium chloride, fused, lump	ton	23 00 – 24 00	24 50 – 28 00
Calcium chloride, granulated	lb.	.01½ – .02	.02½ – .02½
Calcium hypochloride (bleach'g powder)	100 lb.	2 50 – 2 60	2 65 – 3 25
Calcium peroxide	lb.	..... –	1 40 – 1 50
Calcium phosphate, tribasic	lb.	..... –	.15 – .16
Camphor	lb.	..... –	.91 – .95
Carbon bisulphide	lb.	.06½ – .06¾	.07 – .07½
Carbon tetrachloride, drums	lb.	.10½ – .10¾	.11 – .12
Carbonyl chloride, (phosgene)	lb.	..... –	.60 – .75
Caustic potash (see potassium hydroxide)	.....	..... –	..... – .....
Caustic soda (see sodium hydroxide)	....	..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.08 – .09	.09½ – .10
Chloroform	lb.	..... –	.40 – .43
Cobalt oxide	lb.	..... –	2 00 – 2 10
Copperas (see iron sulphate)	.....	..... –	..... – .....
Copper carbonate, green precipitate	lb.	.19 – .19½	.20 – .21
Copper cyanide	lb.	..... –	.50 – .62
Copper sulphate, crystals	100 lb.	5 65 – 5 70	5 75 – 6 25
Cream of tartar (see potassium bitartrate)	.....	..... –	..... – .....
Epsom salt (see magnesium sulphate)	....	..... –	..... – .....
Ethyl Acetate Com. 85%	gal.	..... –	.70 – .80
Ethyl Acetate pure (acetic ether, 98% to 100%)	gal.	..... –	.95 – ....
Formaldehyde, 40 per cent	lb.	.10½ – .11	.11½ – .12
Fusel oil, ref	gal.	..... –	2 50 – 3 00
Fusel oil, crude	gal.	..... –	1 50 – 1 75
Glauber's salt (see sodium sulphate)	....	..... –	..... – .....
Glycerine, C. P. drums extra	lb.	..... –	.15 – .16
Iodine, resublimed	lb.	..... –	3 50 – 3 60
Iron oxide, red	lb.	..... –	.12 – .18
Iron sulphate (copperas)	ton	15 00 – 16 00	17 00 – 20 00
Lead acetate	lb.	..... –	.10½ – .12½
Lead arsenate, powd	lb.	.15 – .15½	.15½ – .16½
Lead nitrate	lb.	..... –	.15 – .20
Litharge	lb.	.08 – .08½	.08½ – .09
Lithium carbonate	lb.	..... –	1 40 – 1 50
Magnesium carbonate, technical	lb.	.07½ – .07¾	.08 – .09
Magnesium sulphate, U. S. P	100 lb.	2 65 – 2 70	2 75 – 3 00
Magnesium sulphate, technical	100 lb.	..... –	1 10 – 1 75
Methanol, 95%	gal.	..... –	.62 – .63
Methanol, 97%	gal.	..... –	.64 – .65
Nickel Salt, double	lb.	..... –	.12 – .12½
Nickel salt, single	lb.	..... –	.14 – .14½
Phosgene (see carbonyl chloride)	.....	..... –	..... – .....
Phosphorus, red	lb.	.45 – .46	.47 – .50
Phosphorus, yellow	lb.	..... –	.32 – .35
Potassium bichromate	lb.	.10½ – .11	.11½ – .11½

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$.... – $....	$0.25½–$0.27
Potassium bromide, granular	lb.	.... –	.15 – .20
Potassium carbonate, U. S. P.	lb.	.15 – .16	.17 – .20
Potassium carbonate, 80–85%	lb.	.04½– .04¾	.05 – .06
Potassium chlorate, crystals	lb.	.05½– .06	.06½– .12
Potassium cyanide	lb.	.... –	.35 – .40
Potassium hydroxide (caustic potash)	lb.	.05¼– .05¾	.06 – .08
Potassium iodide	lb.	.... –	2.60 – 2.75
Potassium nitrate	lb.	.07½– .07¾	.08 – .09
Potassium permanganate	lb.	.15½– .16	.17 – .22
Potassium prussiate, red	lb.	.28 – .29	.29½– .30
Potassium prussiate, yellow	lb.	.22 – .22½	.22½– .23
Rochelle salts (see sodium potas tartrate)	....	....	.... – ....
Salammoniac (see ammonium chloride)	....	....	.... – ....
Sal soda (see sodium carbonate)	....	.... –	.... – ....
Salt cake (bulk)	ton	.... –	17.00 –20.00
Silver cyanide	oz.	.... –	1.10 – 1.20
Silver nitrate	oz.	.... –	.45 – .46
Soda ash, light	100 lb.	1.75 – 2.10	2.15 – 2.50
Soda ash, dense	100 lb.	2.15 – 2.20	2.25 – 2.50
Sodium acetate	lb.	.04 – .04½	.04½– .05
Sodium bicarbonate	100 lb.	2.30 – 2.35	2.40 – 2.75
Sodium bichromate	lb.	.07½– .08	.08¼– .08½
Sodium bisulphate (nitre cake)	ton	5.00 – 5.25	5.50 – 6.50
Sodium bisulphite powdered, U.S.P.	lb.	.04½– .05	.05½– .06
Sodium borate (borax)	lb.	.05¼– .06	.06½– .07
Sodium carbonate (soda)	100 lb.	1.75 – 1.80	1.85 – 2.10
Sodium chlorate	lb.	.06½– .07	.07½– .08
Sodium cyanide	lb.	.27 – .27½	.28 – .30
Sodium fluoride	lb.	.11 – .12	.12½– .14
Sodium hydroxide (caustic soda)	100 lb.	3.80 – 3.85	3.90 – 4.30
Sodium hyposulphite		.... –	.03½– .03¾
Sodium nitrite	lb.	.06¾– .07	.07¼– .07½
Sodium peroxide, powdered	lb.	.25 – .26	.27 – .30
Sodium phosphate, dibasic	lb.	.04½– .04¾	.04¾– .05½
Sodium potassium tartrate (Rochelle salts)	lb.	.... –	.21 – .24
Sodium prussiate, yellow	lb.	.16½– .16¾	.16¾– .17
Sodium silicate, solution (40 deg.)	100 lb.	1.00 – 1.05	1.10 – 1.30
Sodium silicate, solution (60 deg.)	100 lb.	2.30 – 2.40	2.45 – 3.00
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, fused, 60-62 per cent (conc.)	lb.	.04½– .04¾	.04¾– .05
Sodium sulphite, crystals	lb.	.03½– .03¾	.04 – .04½
Strontium nitrate, powdered	lb.	.11 – .12	.12½– .15
Sulphur chloride, red	lb.	.05½– .06	.06¼– .06½
Sulphur, crude	ton	20.00 –22.00	.... – ....
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	.... –	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	.... –	2.00 – 2.75
Tin bichloride	lb.	.09 – .09½	.09¾– .10
Tin oxide	lb.	.... –	.37 – .38½
Zinc carbonate	lb.	.14 – .14½	.15 – .16
Zinc chloride, gran.	lb.	.09 – .09½	.09½– .10
Zinc cyanide	lb.	.42 – .44	.45 – .47
Zinc dust	lb.	.11½– .11½	.11¾– .12½
Zinc oxide, XX	lb.	.07½– .07¾	.08 – .09
Zinc sulphate	100 lb.	3.00 – 3.25	3.30 – 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 — $1.15
Alpha-naphthol, refined	lb.	1.25 — 1.30
Alpha-naphthylamine	lb.	.30 — .32
Aniline oil, drums extra	lb.	.17 — .19
Aniline salts	lb.	.24 — .26
Anthracene, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde U.S.P.	lb.	1.35 — 1.45
Benzidine, base	lb.	.90 — 1.00
Benzidine sulphate	lb	.75 — .85
Benzoic acid, U.S.P.	lb.	.60 — .65
Benzoate of soda, U.S.P.	lb.	.52 — .55
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 — .32
Benzene, 90%, in drums (100 gal.)	gal.	.25 — .28
Benzyl chloride, 95-97%, refined	lb.	.25 — .27
Benzyl chloride, tech	lb.	.20 — .23
Beta-naphthol benzoate	lb.	3.75 — 4.00
Beta-naphthol, sublimed	lb.	.70 — .75
Beta-naphthol, tech	lb.	.30 — .34
Beta-naphthyla mine, sublimed	lb.	1.75 — 1.85
Cresol, U. S. P., in drums (100 lb.)	lb.	.15 — .16
Ortho-cresol, in drums (100 lb.)	lb.	.24 — .26
Cresylic acid, 7–99%, straw color, in drums	gal.	.70 — .80
Cresylic acid, 25-97%, dark, in drums	gal.	.65 — .70
Cresylic acid, 50%, first quality, drums	gal.	.45 — .50
Dichlorbenzene	lb.	.06 — .09
Diethylaniline	lb.	.95 — 1.10
Dimethylaniline	lb.	.40 — .45
Dinitrobenzene	lb.	.23 — .27
Dinitroclorbenzene	lb.	.20 — .25
Dinitronaphthalene	lb.	.30 — .35
Dinitrophenol	lb.	.35 — .40
Dinitrotoluene	lb.	.25 — .30
Dip oil, 25%, car lots, in drums	gal.	.30 — .35
Diphenylamine	lb.	.60 — .70
H-acid	lb.	1.00 — 1.10
Meta-phenylenediamine	lb.	1.10 — 1.15
Monochlorbenzene	lb.	.12 — .14
Monoethylaniline	lb.	1.65 — 1.70
Naphthalene crushed, in bbls.	lb.	.07 — .08
Naphthalene, flake	lb.	.07 — .08
Naphthalene, balls	lb.	.08 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.30 — .35
Nitro-toluene	lb.	.15 — .17
Ortho-amidophenol	lb.	3.00 — 3.10
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.77 — .80
Ortho-nitro-toluene	lb.	.15 — .20
Ortho-toluidine	lb.	.20 — .25
Para-amidophenol, base	lb.	1.40 — 1.45
Para-amidophenol, HCl	lb.	1.70 — 1.80
Para-dichlorbenzene	lb.	.12 — .15
Paranitroaniline	lb.	.77 — .80
Para-nitrotoluene	lb.	.80 — .85
Para-phenylenediamine	lb.	1.70 — 1.75
Para-toluidine	lb.	1.25 — 1.40
Phthalic anhydride	lb.	.37 — .40
Phenol, U. S. P., drums	lb.	.11½ — .15
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	1.50 — 1.60
Resorcinol, pure	lb.	2.00 — 2.25
Salicylic acid, tech., in bbls.	lb.	.20 — .21
Salicylic acid, U. S. P.	lb.	.22 — .23
Salol	lb.	.70 — .72
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 — .28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.14 — .16
Sulphanilic acid, crude	lb.	.27 — .30
Tolidine	lb.	1.30 — 1.35
Toluidine, mixed	lb.	.43 — .45
Toluene, in tank cars	gal.	.25 — .28
Toluene, in drums	gal.	.28 — .31
Xylidines, drums, 100 gal.	lb.	.40 — .45
Xylene, pure, in drums	gal.	.40 — .45
Xylene, pure, in tank cars	gal.	.45 — ....
Xylene, commercial, in drums, 100 gal.	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 — ....

Waxes

Prices based on original packages in large quantities.

Bayberry Wax	lb.	$0.21 — $0.22
Beeswax, refined, dark	lb.	.24 — .25
Beeswax, refined, light	lb.	.28 — .30
Beeswax, white pure	lb.	.34 — .38
Candellila wax	lb.	.24 — .24½
Carnauba, No. 1	lb.	.45 — .46
Carnauba, No. 2, North Country	lb.	.23½ — .24
Carnauba, No. 3, North Country	lb.	.13½ — .14
Japan	lb.	.21 — .21½
Montan, crude	lb.	.04½ — .04½
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.04½ — .04½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.03½ — ....
Paraffine waxes, refined, 118-120 m.p.	lb.	.03¾ — .04
Paraffine waxes, refined, 125 m.p.	lb.	.04 — .04½
Paraffine waxes, refined, 128-130 m.p.	lb.	.04½ — .04¾
Paraffine waxes, refined, 133-135 m.p.	lb.	.05 — .05½
Paraffine waxes, refined, 135-137 m.p.	lb.	.05½ — .05½
Stearic acid, single pressed	lb.	.09½ — ....
Stearic acid, double pressed	lb.	.09½ — ....
Stearic acid, triple pressed	lb.	.10½ — .10¾

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	$5.30	— 5.35
Rosin E-I	280 lb.	5.40	— 5.50
Rosin K-N	280 lb.	6.05	— 6.75
Rosin W. G.-W. W.	280 lb.	7.00	— 7.25
Wood rosin, bbl.	280 lb.	6.25	— ....
Spirits of turpentine	gal.	.82	— ....
Wood turpentine, steam dist.	gal.	.80	— ....
Wood turpentine, dest. dist.	gal.	.78	— ....
Pine tar pitch, bbl.	200 lb.	....	— 6.00
Tar, kiln burned, bbl. (500 lb.)	bbl.	....	— 9.50
Retort tar, bbl.	500 lb.		— 9.50
Rosin oil, first run	gal.	.36	— ....
Rosin oil, second run	gal.	.39	— ....
Rosin oil, third run	gal.	.46	— ....
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.90
Pine oil, pure, dest. dist.	gal.		1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.35
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.35
Pinewood creosote, ref	gal.		.52

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.37
70-72 deg., steel bbls. (85 lb.)	gal.	.35
68-70 deg., steel bbls. (85 lb.)	gal.	.34
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23

Fertilizers

Ammonium sulphate, bulk and d. bags	100 lb.	$2.30	— 2.90
Blood, dried, f.o.b., N. Y.	unit	4.00	
Bone, 3 and 50, ground, raw	ton	30.00	— 32.00
Fish scrap, dom., dried, f.o.b. works	unit	2.90	— 3.00
Nitrate soda	100 lb.	2.30	— 2.35
Tankage, high grade, f.o.b. Chicago	unit	2.75	— 3.00
Phosphate rock, f.o.b. mines, Florida pebble, 68-72 p.c.	ton	4.50	— 6.50
Tennessee, 78-80 p.c.	ton	8.50	— 9.00
Potassium muriate, 80 p.c.	ton	34.00	— 35.00
Potassium sulphate	unit	.90	— 1.00

Crude Rubber

Para—Upriver fine	lb.	$0.23	— .23½
Upriver coarse	lb.	.13½	— .14
Upriver caucho ball	lb.	.13	— .13½
Plantation—First latex crepe	lb.	.18½	— .18½
Ribbed smoked sheets	lb.	.18¼	— .19
Brown crepe, thin, clean	lb.	.15	— ....
Amber crepe No. 1	lb.	.17½	— ....

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.10½	— $0.10¾
Castor oil, AA, in bbls.	lb.	.11½	— .12
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.13½	— .13¾
Cocoanut oil, Ceylon grade, in bbls.	lb.	.09½	— .09¾
Cocoanut oil, Cochin grade, in bbls.	lb.	.10½	— .10¾
Corn oil, crude, in bbls.	lb.	.08¼	— .08½
Cottonseed oil, crude (f. o. b. mill)	lb.	.07	— .07½
Cottonseed oil, summer yellow	lb.	.08½	— .09
Cottonseed oil, winter yellow	lb.	.09½	— .09¾

Linseed oil, raw, car lots (domestic)	gal.	.67 —	.68
Linseed oil, raw, tank cars (domestic)	gal.	.62 —	.63
Linseed oil, in 5-bbl lots (domestic)	gal.	.70 —	.71
Olive oil, Denatured	gal.	$1.15 —	$1.20
Palm, Lagos	lb.	.07½ —	.08
Palm, Niger	lb.	.06½ —	.06¾
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.08¼ —	.08½
Peanut oil, refined, in bbls	lb.	.11 —	.11½
Rapeseed oil, refined in bbls	gal.	.84 —	.85
Rapeseed oil, blown, in bbls	gal.	.88 —	.90
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.08½ —	....
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.07½ —	....
FISH			
Light pressed menhaden	gal.	$0.40 —	....
Yellow bleached menhaden	gal.	.42 —	....
White bleached menhaden	gal.	.45 —	....
Blown menhaden	gal.	.48 —	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$23.00 —	23.50
Barytes, ground, off color, f.o.b. Kings Creek	net ton	15.00 —	17.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00 —	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00 —	24.00
Barytes, crude, first grade, Missouri	net ton	6.00 —	7.00
Blanc fixe, dry	lb.	.04 —	.04½
Blanc fixe, pulp	net ton	45.00 —	55.00
Casein	lb.	.15 —	.16
Chalk, Precipitated, domestic, extra light	lb.	.04½ —	.05
Chalk, Precipitated, domestic, light	lb.	.04 —	.04½
Chalk, Precipitated, domestic, heavy	lb.	.03½ —	.04
Chalk, Precipitated, English, extra light	lb.	.04½ —	.05
Chalk, Precipitated, English, light	lb.	.04½ —	.05
Chalk, Precipitated, English, dense	lb.	.04 —	.04½
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50 —	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00 —	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	13.00 —	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00 —	12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	13.00 —	20.00
China clay (kaolin), imported, lump	net ton	12.00 —	20.00
China clay (kaolin), imported, powdered	net ton	25.00 —	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00 —	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50 —	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00 —	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00 —	30.00
Fullers earth, f.o.b. Mines	net ton	16.00 —	17.00
Fullers earth, granular, f.o.b. Fla	net ton	15.00 —	18.00
Fullers earth, powdered, f.o.b. Fla	net ton	18.00 —	....
Fullers earth, imported, powdered	net ton	24.00 —	27.00
Graphite, Ceylon lump, first quality	lb.	.05½ —	.06½
Graphite, Ceylon chip	lb.	.04 —	.05
Graphite, high grade amorphous crude	lb.	.00½ —	.02½
Kieselguhr, f.o.b. mines, Cal	per ton	40.00 —	....
Kieselguhr, f.o.b. N.Y.	per ton	55.00 —	60.00
Magnesite, calcined	per ton	50.00 —	65.00
Pumice stone, imported	lb.	03 —	.40
Pumice stone, domestic, lump	lb.	.05 —	.05½
Pumice stone, domestic, ground	lb.	.06 —	.07
Quartz (acid tower) first to bead, f.o.b. Baltimore	net ton	..... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	..... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	..... —	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00 —	7.50
Shellac, orange fine	lb.	.68 —	.70
Shellac, orange superfine	lb.	.78 —	.80
Shellac, A. C. garnet	lb.	.58 —	.60
Shellac, T. N.	lb.	.68 —	.70
Soapstone	ton	12.00 —	15.00
Sodium chloride	long ton	12.50 —	13.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.25 —	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50 —	11.00
Talc, imported	ton	30.00 —	40.00
Talc, California talcum powder grade	ton	18.00 —	25.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton		$50.00
Carborundum refractory brick, 9-in.	less than carlot	1,000	1250.00
	carload lots	1,000	1100.00
Chrome brick, f.o.b. Eastern shipping points	net ton		52– 55
Chrome cement, 40–45% Cr_2O_3	net ton		30– 32
Chrome cement, 40–45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton		33– 35
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		35– 40
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		30– 35
Magnesite brick, 9-in. straight	net ton		65– 70
Magnesite brick, 9-in. arches, wedges and keys	net ton		77
Magnesite brick, soaps and splits	net ton		98
Silica brick, 9-in. sizes, f.o.b Chicago district	1,000		40– 42
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000		42– 45
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000		35– 38

Ferro-Alloys

All f.o.b. Works

Ferrocarbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$225.00
Ferrochrome per lb. of Cr. contained, 6–8% carbon, carlots	lb.	.12 —	....
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.13 —	....
Ferromanganese, 76-80% Mn, domestic	gross ton	58.00 —	60.00
Ferromanganese, 76-80% Mn, Foreign, C. I. F. Atlantic Seaport	gross ton	54.00 —	58.35
Spiegeleisen, 18-22% Mn	gross ton	25.00 —	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25 —	....
Ferrosilicon, 10-15%	gross ton	38.00 —	40.00
Ferrosilicon, 50%	gross ton	57.00 —	59.00
Ferrosilicon, 75%	gross ton	120.00 —	125.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40 —	.45
Ferrouranium, 35-50% of U, per lb.of U content	lb.	6.00 —	....
Ferrovanadium, 30-40% per lb. of contained V.	lb.	4.25 —	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	$8.00 —	$10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	ton	22.00 —	23.00
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	ton	22.00 —	23.00
Coke, foundry, f.o.b. ovens	net ton	4.25 —	4.50
Coke, furnace, f.o.b. ovens	net ton	3.25 —	3.50
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	12.00 —	.....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00 —	22.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½ —	.01¾
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.23 —	.24
Manganese ore, chemical (MnO_2)	net ton	55.00 —	60.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.45 —	.50
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	30.00 —	.....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13 —	.13
Pyrites, domestic, fines, f.o.b. mines, Ga	unit	.11 —	.12
Rutile, 95% TiO_2 per lb. ore	lb.	.15 —	.....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	2.50 —	2.75
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	2.75 —	3.00
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.25 —	1.75
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25 —	2.50
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.00 —	.....
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	.04½ —	.13

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	13.75
Aluminum, 98 to 99 per cent.	19.00
Antimony, wholesale lots, Chinese and Japanese	4.50
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, shot and blocks	35.00
Monel metal, ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	33.00
Lead, New York, spot	4.70
Lead, E. St. Louis, spot	4.35@4.40
Zinc, spot, New York	5.25@5.30
Zinc, spot, E. St. Louis	4.80@4.85

OTHER METALS

Silver (commercial)	oz.	$0.65½
Cadmium	lb.	1.00–1.25
Bismuth (500 lb. lots)	lb.	1.50@1.55
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	75.00–78.00
Iridium	oz.	150.00@170.00
Palladium	oz.	55.00–60.00
Mercury	75 lb.	48.00–49.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	21.25
Copper bottoms	28.75
Copper rods	19.75
High brass wire	17.25
High brass rods	14.75
Low brass wire	18.75
Low brass rods	19.25
Brazed brass tubing	25.50
Brazed bronze tubing	30.50
Seamless copper tubing	21.25
Seamless high brass tubing	18.50

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	Cleveland	Chicago
Copper, heavy and crucible	9.75@10.25	9.25	9.50
Copper, heavy and wire	9.25@ 9.50	8.50	8.50
Copper, light and bottoms	7.50@ 8.00	7.50	7.25
Lead, heavy	3.50@ 3.75	3.25	3.25
Lead, tea	2.25@ 2.35	2.25	2.25
Brass, heavy	4.25@ 4.50	4.50	5.00
Brass, light	3.25@ 3.50	3.25	3.50
No. 1 yellow brass turnings	4.00@ 4.25	4.25	4.50
Zinc	2.00@ 2.25	2.00	2.25

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	$2.78	$2.88	$2.78
Soft steel bars	2.68	2.78	2.68
Soft steel bar shapes	2.68	2.78	2.68
Soft steel bands	3.28	3.48	3.28
Plates, ¼ to 1 in. thick	2.78	2.88	2.78

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arkansas

LITTLE ROCK—A. B. Banks, Little Rock, and Burton B. Tuttle, Cincinnati, O., are organizing a new company for the operation of a plant for the manufacture of fertilizer, whiting and kindred products on property recently acquired at White Cliffs on the Little River, between Nashville and Ashdown, Ark. The site totals over 2,500 acres of land and was obtained for a consideration said to be about $500,000. A chalk works will also be established in connection with the project. The new company will operate with a capital of $1,000,000.

FORT SMITH—The Crystal Glass Co., Ninth and O Sts., is planning for the remodeling of its plant, with extensions and improvements estimated to cost about $75,000. C. P. Zenor heads the company.

California

CHICO—The Shell Oil Co., 343 Sansome St., San Francisco, has plans under way for the construction of a new distributing plant on a 2-acre plot of ground, known as the Thompson property, Chico, estimated to cost about $60,000, including equipment.

Colorado

GRAND JUNCTION—The Grand Junction Gas Co. plans an expenditure of $25,000 for the enlargement of its plant. J. Stewart is general superintendent.

Connecticut

BRIDGEPORT—The D. & C. Oil Co., Lindley St., has completed plans for the erection of a new 1-story plant, 25 x 80 ft., on Colonial Ave., estimated to cost about $25,000.

Indiana

MICHIGAN CITY—A 1-story foundry addition, with power plant, estimated to cost about $500,000, including machinery, will be erected at the plant of the Haskell & Barker Car Co. Bids have been taken. Frank D. Chase, Inc., 545 North Michigan Ave., Chicago, Ill., is architect and engineer.

Kentucky

CORBIN—The Corbin Brick Co. is planning for extensions in its plant to increase the capacity from about 15,000 to 30,000 bricks per day. Two new kilns will be constructed, drier equipment and other apparatus installed. The company has recently increased its capital from $50,000 to $100,000 for expansion. Benn Goodwin is manager.

Louisiana

KENNER—The National Petroleum Co., Hibernia Bank Bldg., New Orleans, La., is planning for the erection of a new oil-refining plant in the vicinity of Kenner, La. P. A. Leslie is manager.

GRETNA—The United States Flour Mills Co., 606 Common St., New Orleans, is perfecting plans for the erection of a new flour mill at Gretna, with initial capacity of about 6,000 bbl. of flour per day. An extensive laboratory will be established in connection with the works. W. L. O'Daniel is president.

ALEXANDRIA—The Alexandria Refining Co., recently organized, has construction under way on a new local oil refinery for the production of gasoline, kerosene and petroleum byproducts. It is proposed to have the plant ready for service at an early date. E. M. Talley is general manager.

Maryland

BALTIMORE—The Bethlehem Steel Co., Bethlehem, Pa., has preliminary plans under way for extensions and improvements in its local plant, estimated to cost close to $50,000,000. The plans are being developed and will provide, it is said, for about twice the present output. The present plant, known as the Sparrow Point Works, represents an investment of more than $70,000,000.

BALTIMORE—The Central Chemical Co. has acquired the plant of the D. B. Marton Co., 1630 Clinton St., and will use the property for a new chemical manufacturing works. Possession will be taken at once.

BALTIMORE—The National Wall Paper Co., 1009 East Baltimore St., has had plans prepared for the erection of an addition, 40 x 100 ft., to its 3-story building at 706 East Baltimore St.

BALTIMORE—The new oil refinery now being constructed by the Standard Oil Co. is estimated to represent a total investment of $7,000,000, and will rank as the second largest plant of its kind in the world. It will be placed in operation as soon as completed. The company will build a new tankage department at First Ave. and Fourteenth St., to cost about $30,000.

Massachusetts

WALTHAM—The Elastoid Fiber Co., Norman and Marshall Sts., has construction under way on a new 1-story plant, 72 x 180 ft., in the vicinity of Pond St. It is expected to be ready for occupancy at an early date. A 1-story power house will also be constructed. The H. P. Cummings Construction Co., Ware, Mass., has the erection contract.

Michigan

BAY CITY—The Aetna Portland Cement Co., Union Trust Bldg., Detroit, has acquired property at Bay City, totaling about 30 acres, as a site for the erection of a large cement-manufacturing plant. Preliminary plans are under way for the first plant unit, designed in the form of an inverted U, with total area 375 x 900 ft. It will consist of a grinding department, 60 x 60 ft.; cooling department; 3 kilns; machine repair shop; coaling department; and power plant. Docks and other transportation facilities will be constructed. The plant unit will have an initial minimum output of about 300 bbl. per day, and is estimated to cost close to $750,000. It is proposed to commence erection early in the spring. The plant will be operated in conjunction with the present works of the company at Fenton, Mich. Franklin R. Robinson is president; and O. J. Lingeman, secretary.

Missouri

MARSTON—The East St. Louis Cotton Oil Co., is planning for the rebuilding of the portion of its local plant, recently destroyed by fire with loss of about $30,000.

ST. LOUIS—The Red Spot Paint & Varnish Co., 1534 North Eighth St., is perfecting plans for the immediate remodeling and improving of the 3-story factory, 40 x 125 ft., recently acquired, for the establishment of a new plant for the manufacture of paints and vernishes for industrial and other service. P. C. Fryaser is general manager.

New Jersey

JERSEY CITY—The Ault & Wiborg Chemical Co., 432 New St., Cincinnati, O., manufacturer of printing inks, etc., has acquired the property of the Cockburn Corp., Monmouth and Twelfth Sts., Jersey City, including land and buildings, and will occupy the premises for a plant.

EAST ROCHESTER—The Merchants' Dispatch Transportation Co., has completed plans and will soon commence the erection of a 1-story addition to its steel-fabricating plant, 60 x 80 ft. L. F. West is head.

CUYLERVILLE—The Sterling Salt Co., 29 Broadway, New York, has awarded a contract to Dwight P. Robinson & Co., 126 East Forty-Sixth St., for the erection of a new building at Cuylerville.

Ohio

AKRON—The National Sulphur Co., 80 Maiden Lane, New York, has completed plans and will take bids at once for the construction of a new sulphur plant on Talmadge Road, Akron, to consist of four 1-story buildings, estimated to cost about $300,000, including machinery. C. S. Clark, 212 Ohio Bldg., Akron, is engineer.

AKRON—The Seiberling Rubber Co., recently organized under Delaware laws, is arranging for a stock issue of $2,000,000, the proceeds to be used for general operations, expansion, etc. The company proposes to develop a capacity of about 5,000 automobile tires and 6,000 tubes daily at its two plants at New Castle, Pa., and Barberton, Ohio, the latter comprising the former works of the Portage Rubber Co., lately purchased. Cord tires, also, will be manufactured at the plants. F. A. Seiberling, formerly president of the Goodyear Tire & Rubber Co., is president; and C. W. Seiberling, vice-president.

Oklahoma

MUSKOGEE—The Muskogee Vitrified Brick Co. is planning for the rebuilding of the portion of its plant recently destroyed by fire with loss estimated at about $50,000, including equipment.

Pennsylvania

BRACKENBRIDGE—The Atlantic Bottle Co. has construction in progress for a new 2-story plant, 100 x 250 ft., estimated to cost about $35,000. Allan & Kestner, Tarentum, Tarentum, Pa., are architects.

PITTSBURGH—The Neely Oil & Production Co., Pittsburgh, is planning for the establishment of a new oil-refining plant on a site in Allen County, Ky. It is said that work will be inaugurated at an early date.

DERRY—The Pittsburgh High Voltage Insulator Co., is considering tentative plans for the erection of an addition to its plant.

Tennessee

NASHVILLE—Mercer Reynolds, Chattanooga, Tenn., is perfecting plans for the organization of a new company, to construct and operate a plant at Nashville, where a site has been acquired. The new plant will manufacture paper products from cotton linters, under a special process. A specialty will be made of fine bond papers.

Texas

WACO—William Sacks, Tulsa, Okla., is planning for extensions and improvements in the local refinery of the Waco Refining Co., recently acquired. The present capacity of 5,000 bbl. per day will be increased. A new pipeline will be constructed from Mexia to Waco. The entire project is estimated to cost in excess of $750,000, including equipment.

PORT ARTHUR—Fire, Dec. 5, destroyed a portion of the local oil refinery of the Texas Co., Dallas, Tex. The loss, official estimate of which has not been made, included high pressure stills and other equipment.

Virginia

RICHMOND—George Gibson, Richmond Trust Co. Bldg. Seventh and Main Sts., operating the Industrial Realty Corp., has awarded a contract to John T. Wilson & Co., Inc., Mutual Bldg., for the erection of a new 1-story and basement plant, 102 x 202 ft., at Seventh and Everett Sts., to be equipped for the manufacture of paper products. It is estimated to cost about $75,000. Carneal & Johnston, Chamber of Commerce Bldg., are architects.

West Virginia

SALEM—The Salem Flint Glass Co., recently organized, will install considerable glass-manufacturing equipment in an existing building, for the manufacture of shades, globes and kindred glass specialties. R. F. Davis is president, and J. O. Burkhard, general manager.

WHEELING—The Wheeling Mold & Foundry Co. has extensive improvement work under way at its plant, including the remodeling of certain departments and equipment. The plant will be placed in operation, it is said, at an early date.

Wisconsin

GREEN BAY—The Fort Howard Paper Co. has active construction under way on a new 3-story paper mill, 100 x 120 ft., in the East Side section, estimated to cost about $85,000. The plant will be occupied as soon as completed.

Ontario

LONDON—The Board of Education asks for bids on complete equipment for chemistry and physics laboratories for a new high school, estimated cost $15,000. L. E. Carrothers is the engineer..

New Companies

THE WAXTWELL PAPER CO., Grand Rapids, Mich., has been incorporated with a capital of $10,000, to manufacture waxed, plain and other papers. The incorporators are Archibald I. McCall, Grand Rapids; John F. Hastings, Jr., and George J. Putt, Kalamazoo, Mich.

THE AMERICAN ALUMINUM CASTING CO., Newark, N. J., has been incorporated with a capital of $25,000, to manufacture aluminum and other metal castings. The incorporators are John Rohn, Frank T. Schmuchl and Henry Brucker, 324 Colt St., Newark.

THE METROPOLITAN POTTERY CO., Woodhaven, L. I., has been incorporated with a capital of $50,000, to manufacture pottery products of various kinds. The incorporators are A. and H. Ratner, and N. McCoy. The company is represented by W. Augenmeyer, Woodhaven.

THE SALUTARAS DRUG & CHEMICAL CO., 1707 South Halsted St., Chicago, Ill., has been incorporated with a capital of $5,000, to manufacture chemicals, drugs, etc. The incorporators are M. K. Wood, Stanley Darguzis and William Picktorman.

THE GARDNER-HART CHEMICAL CORP., Wilmington, Del., has been incorporated under state laws with capital of $1,000,000, to manufacture chemicals and chemical byproducts. The company is represented by the Delaware Registration Trust Co., 900 Market St., Wilmington.

THE GLO-RITE CO., Camden, N. J., has been incorporated with a capital of $100,000, to manufacture polishes and kindred specialties. The incorporators are Edward S. Gille, James D. Eastnick and Harold W. Bennett, 45 North Third St., Camden.

THE SAGAMORE OIL CORP., Grandfield, Okla., has been incorporated with a capital of $100,000, to manufacture petroleum products. The incorporators are Homer D. Cris, and W. S. Hamilton, both of Grandfield; and H. P. Downs, Tulsa, Okla.

THE SOUTHBRIDGE FOUNDRY CO., Southbridge, Mass., has been incorporated with a capital of $30,000, to manufacture iron, steel and other metal castings. Frank S. Mills is president; and Arthur A. Allard, Southbridge, treasurer.

THE M-S POLAR-PROOF CO., Room 623, 53 West Jackson St., Chicago, Ill., has been incorporated with a capital of $10,000, to manufacture varnishes, polishes, carbon removers, etc. The incorporators are John F. Ashworth, Judson G. Hancock and Robert M. Sherritt.

RESPRO, INC., Cranston, R. I., has been incorporated with a capital of $100,000 to manufacture rubber products. The incorporators are Eugene A. Kingman, Walter A. Edwards and Kenneth J. Tanner, all of Providence, R. I.

H. MURDOCH & CO., Wilmington, Del., has been incorporated under state laws with a capital of $100,000, to operate a metal smelting and refining plant; converting ores, etc. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE HEINEMANN & MOSCH GLASS & MIRROR CO., Newark, N. J., has been incorporated with a capital of $50,000, to manufacture glass products, mirrors, etc. The incorporators are Otto Heinemann, Joseph Mosch and Frank Prasch. The company is represented by Howard Ishewood, 738 Broad St., Newark.

THE HERCULES CHEMICAL CO., Wilmington, Del., has been incorporated with a capital of $100,000 under state laws, to manufacture chemicals and affiliated products. The company is represented by Franklin L. Mettler, 832 Market St., Wilmington.

THE FAIRMONT OIL CO., Woonsocket, R. I., has been incorporated with a capital of $25,000, to manufacture oil products. The incorporators are A. E., R. A., and Lumina D. Bonin, all of Woonsocket.

THE ARTCRAFT PAPER BOX CO., 154 Whiting St., Chicago, Ill., has been incorporated with a capital of 250 shares of stock, no par value, to manufacture paper boxes and containers. The incorporators are James H. Cartwright, Jr.; Harold Beacon and R. S. Tuthill.

THE NEW JERSEY LEATHER GOODS CO., Jersey City, N. J., has been incorporated with a capital of $100,000, to manufacture leather products. The incorporators are Herbert W. Royal, Edwin G. Adams and Herman B. Welch, 542 Palisade Ave., Jersey City.

THE RELIANCE OIL CO., Los Angeles, Cal., has been incorporated with a capital of $1,000,000, to manufacture petroleum products. The incorporators are F. G. Howland, L. Volk and G. J. Knight, all of Los Angeles. The company is represented by Carnahan & Clark, 756 South Broadway, Los Angeles.

THE RIO GRANDE PAINT CO., Laredo, Tex., has been incorporated with a capital of $15,000, to manufacture paints, varnishes, etc. The incorporators are W. L. Guyler and E. H. Buenz, both of Laredo.

THE GREAT SOUTHERN STEEL CO., Chicago, Ill., has been incorporated under Delaware laws with capital of $105,000,000, to manufacture steel products. The company is represented by Charles E. Pain, First National Bank Bldg., Chicago.

GEORGE J. YOUNG, INC., Brooklyn, N. Y., has been incorporated with a capital of $100,000, to manufacture chemicals and chemical byproducts, drugs, etc. The incorporators are George J. and R. Young. The company is represented by I. Cook, 189 Montague St., Brooklyn.

Capital Increases, Etc.

THE OCCIDENTAL OIL CO., Mexia, Tex., has been incorporated with a capital of $500,000, to manufacture petroleum products. The incorporators are Frank Smith, S. E. Colgin and A. E. Wilder, all of Mexia.

THE POLO CHEMICAL CO., 2824 West Chicago Ave., Chicago, Ill., has been incorporated with a capital of $25,000, to manufacture chemicals and chemical byproducts. The incorporators are Michael Schwetz and Leon Segel.

THE EASTERN ALUMINUM CO., Pittsburgh, Pa., has been incorporated with a capital of $300,000, under Delaware laws, to manufacture aluminum and other metal products. The incorporators are George V. Brooke, Pittsburgh; John J. Hughes, New Florence, Pa.; and J. V. Hughes, Johnstown, Pa.

THE TRINITY OIL CORP., Dallas, Tex., has been incorporated with a capital of $400,000, to manufacture petroleum products. The incorporators are Harry Pennington, Frank D. Halm and J. W. Ricker, all of Dallas.

THE COMMERCIAL CHEMICAL CO., 23-25 Light St. Baltimore, Md., has been incorporated with a capital of $10,000, to manufacture chemicals and chemical byproducts. The incorporators are Edward S. Tyler, Charles E. Callis and William F. Hammond.

THE WEST BRANCH TANNING CO., Philadelphia, Pa., has been incorporated with a capital of $5,000, to manufacture leather products. W. S. Anderson, 2241 North 53d Street, is treasurer.

THE CAFICO CHEMICAL CO., Pittsburgh, Pa., has been incorporated under Delaware laws with capital of $50,000, to manufacture chemicals and chemical byproducts. The company is represented by the Capital Trust Co., Dover, Del.

THE OIL DESULPHURIZING CORP., New York, N. Y., has been incorporated with a capital of $1,500,000, under Delaware laws, to manufacture refined oil products. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

THE MUTUAL PETROLEUM CORP., Adrian, Mich., has filed notice of increase in capital from $25,000 to $100,000.

THE CLAY-GODSON CORP., 2413 Third Ave., New York, N. Y., has filed notice of dissolution under state laws.

THE PURE OIL CO., 74 Broadway, New York, N. Y., has arranged for a preferred stock issue to total $4,300,000, for general operations, financing, etc.

THE WARNER SUGAR REFINING CO., 79 Wall St., New York, N. Y., has disposed of a bond issue of $6,000,000, the proceeds to be used for general operations, financing, etc.

THE NATIONAL LEATHER CO., 161 South St., Boston, Mass., has been reorganized with a capital of $7,500,000, a reduction of $22,500,000 from the former capitalization. Stockholders have approved plans for a preferred stock issue to total $15,000,000.

THE PIERCE OIL CORP., 25 Broad St., New York, N. Y., has arranged for a bond issue of $2,000,000, the proceeds to be used for general operations, financing, etc.

THE ELECTRIC ALLOY STEEL CO., Charleroi, Pa., has perfected arrangements for a preferred stock issue to total $750,000, the proceeds to be used for additional working capital, plant extensions and improvements, etc.

Following the acquisition of the APSLEY RUBBER CO., Marlboro, Mass., by the Firestone Tire & Rubber Co., Akron, O., notice has been filed of change of name to the Firestone-Apsley Rubber Co.

Industrial Notes

W. F. LEGGET, former advertising manager of the Webster Manufacturing Co., Chicago, has become associated with the Chemical Catalog Co. as Western sales manager, with headquarters in Chicago.

THE UNION SULPHUR CO.'S New York office is now located in the Frasch Bldg., 32 Rector St., a new 15-story building named in honor of the founder of the Union Sulphur Co.

J. DOL & CIE., 30 Rue Pertinax, Nice, France, inform us that they hold options on large deposits of bauxite in southern France.,

THE INSULATION & SPECIALTY CORP. OF AMERICA, du Pont Bldg., Wilmington, Del., has been incorporated for the manufacture of insulating material known as fiber granite. The material will be produced in sheets, tubes and rods.

THE W. A. JONES FOUNDRY & MACHINE CO., manufacturer of power transmitting machinery, announces the appointment of Fred E. Holtz as its Milwaukee district representative. He will assume his new duties immediately, making headquarters in the First National Bank Bldg.

THE COMBUSTION ENGINEERING CORP., New York, announces the recent opening of two branch offices: One at 216 Latta Arcade, Charlotte, N. C., in charge of T. E. Nott; the other at Seattle, Wash., where it is represented by the Fryer-Barker Co., 1133 Henry Bldg.

THE CHLORINE PRODUCTS CO., Chicago, Ill., announces that it is now ready to market its line of electrolytic cells, gas compressors, gas controllers, condensers, etc., for the production of chlorine gas, caustic alkalis, hydrogen gas and liquid chlorine. W. M. Jewell is secretary of the company.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its seventy-fourth meeting at Toronto, Canada, Dec. 26 to 31, 1921.

AMERICAN CERAMIC SOCIETY will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 2, 1922.

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922.

AMERICAN ENGINEERING COUNCIL will hold its next meeting in Washington, Jan. 5-6.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Cleveland, O., during the week of April 24, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York the week of Feb. 20, 1922.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

PERKIN MEDAL will be presented to William M. Burton by the Society of Chemical Industry at its meeting Jan. 13 at the Chemists' Club, New York.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Jan. 6—American Chemical Society, regular meeting; Jan. 13—Society of Chemical Industry, Perkin Medal; Feb. 10—American Electrochemical Society (in charge), Society of Chemical Industry, Société de Chimie Industrielle, American Chemical Society, joint meeting; March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.